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EVALUATION OF SULFUR DIOXIDE EMISSION CONTROL OPTIONS FOR IOWA POWER BOILERS

D. O. Moore, Jr., et al

M. W. Kellogg Company

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16. ABSTRACT

The report gives results of an evaluation of SO_2 emission control strategies for major coal burning boilers in Iowa, considering options such as using low-sulfur Eastern and Western coals, mechanical coal cleaning, and flue gas desulfurization (FGD). Major utility boilers were surveyed, probable coal sources were determined, and alternate transportation routes were defined. Coal cleaning plant and FGD design studies were performed. Cost data were generated and a linear computer program model was developed to determine minimum cost strategies for meeting emission levels corresponding to no-control and control to 5.0, 3.1 and 1.2 lb SO_2/MM Btu. For the cases studied, FGD was most cost effective only for the most restrictive emission level (1.2 lb/MM Btu) and when the supply of low-sulfur coal was limited. Importing low-sulfur Eastern and Western coals or combinations of mechanical coal cleaning and low-sulfur coal import gave the lowest cost for all other cases. These conclusions are not generally applicable to other states because of differences in the distances low-sulfur coal must be transported, the washability characteristics of local coals, the size of the power plants, the power plant network and other factors.

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TABLE OF CONTENTS

Page No.

I. Introduction 1

II. Summary and Conclusions 6

III. Overall System Evaluation 30

- A. Basic Assumptions Made for the System to Use in the Linear Computer Program 31
- **B. Linear Computer Program Results** 38

IV. Process Descriptions 44

- A. Flue Gas Scrubbing Processes 44
  1. Wet Limestone System
  2. Wellman-Lord System
  3. Allied System
- **B. Coal Cleaning Process** 58

V. Descriptions of Power Plants in Iowa 62

VI. Estimates for Flue Gas Scrubbing 90

- A. Detailed Estimates for Wet Limestone Systems 90
- B. Computerized Estimates for Both Scrubbing Systems 94
  1. Wet Limestone Cost Model
  2. Wellman-Lord/Allied Cost Model
- **C. Comparative Economics of Wet Limestone** vs. Wellman-Lord/Allied 105

VII. Linear **Programming Model** 115

- A. **A Brief Discussion of Linear Programming** 115
- B. **The Definition of the Problem in Terms of an LP Model** 118
- C. **Solution Using KELPLANS** 125

Page No.

VIII. References 139

IX. Glossary 141

X. Appendices 143

A. Power Plant Input Data 144

B. Wet Limestone System 183

B-1. Process Flow Sheets
B-2. Equipment List
B-3. Standard Scrubber Modules
B-4. Standard Sizes for Venturi Scrubbers and Absorbers
B-5. Standard Limestone System - Plan & Elevation
B-6. Sludge Pond Size Sheet
B-7. Plot Plans for Each Plant - Wet Limestone Systems Added

C. Wellman-Lord/Allied System 205

C-1. Process Flow Sheets
C-2. Equipment List
C-3. Standard Scurbber Module
C-4. Standard Wellman-Lord System Plan
C-5. Standard Component Sizes
C-6. Plot Plans for Each Plant - Wellman-Lord/Allied Systems Added

D. Coal Cleaning System 225

D-1. Process Flow Sheet
D-2. Equipment List
D-3. Simplified Plot Plan - Typical 600 TPH Plant

E. Plot Plans of Other Power Plants 230

F. Conversion from English to Metric Units 237

G. Linear Computer Program Print-outs (Abridged) 239

LIST OF FIGURES

Figure No.	Title	Page No.
1	Plot of Incremental System Costs vs. SO_2 Emission Specification	43
2	Scrubbing System Costs vs. % Sulfur	114
3	Wet Limestone Scrubbing Costs Used in Linear Program	127
4	Coal Cleaning Costs Used in Linear Program	128
5	Process Flow Diagram - Limestone and Effluent System	184
6	Process Flow Diagram - Scrubber System	185
7	Standard Scrubber Module - Type A: Size I	190
8	Standard Scrubber Module - Type B: Size I	191
9	Standard Scrubber Module - Type C: Size I	192
10	Standard Limestone System - Plan and Elevation	195
11	Plot Plan - Des Moines Plant - Wet Limestone Scrubbing System	197
12	Plot Plan - Maynard Plant - Wet Limestone Scrubbing System	198
13	Plot Plan - Muscatine Plant - Wet Limestone Scrubbing System	199
14	Plot Plan - Riverside Plant - Wet Limestone Scrubbing System	200
15	Plot Plan - Burlington Plant - Wet Limestone Scrubbing System	201
16	Plot Plan - Kapp Plant - Wet Limestone Scrubbing System	202
17	Plot Plan - Prairie Creek Plant - Wet Limestone Scrubbing System	203
18	Plot Plan - Sutherland Plant - Wet Limestone Scrubbing System	204
19	Process Flow Diagram - Wellman-Lord Process	206
20	Process Flow Diagram - Allied Chemical Process	207
21	Standard Scrubber Module - Wellman-Lord Process	214
22	Standard Module Plans - Wellman-Lord/Allied Process	215

LIST OF FIGURES CON'T.

Figure No.	Title	Page No.
23	Plot Plan - Des Moines Plant - Wellman-Lord/Allied Process	217
24	Plot Plan - Maynard Plant - Wellman-Lord/Allied Process	218
25	Plot Plan - Muscatine Plant - Wellman-Lord/Allied Process	219
26	Plot Plan - Riverside Plant - Wellman-Lord/Allied Process	220
27	Plot Plan - Burlington Plant - Wellman-Lord/Allied Process	221
28	Plot Plan - Kapp Plant - Wellman-Lord/Allied Process	222
29	Plot Plan - Prairie Creek Plant - Wellman-Lord/Allied Process	223
30	Plot Plan - Sutherland Plant - Wellman-Lord/Allied Process	224
31	Process Flow Diagram - Coal Cleaning Process	226
32	Simplified Plot Plan - Coal Cleaning Plant	229
33	Plot Plan - Pella Plant	231
34	Plot Plan - Iowa State University Plant	232
35	Plot Plan - Fair Plant	233
36	Plot Plan - Dubuque Plant	234
37	Plot Plan - Lansing Plant	235
38	Plot Plan - Sixth Street Plant	236

LIST OF TABLES

Table No.	Title	Page No.
1	Case 1 - Summary of Costs	40
2	Case 2 - Summary of Costs	41
3	Case 3 - Summary of Costs	42
4	Economic Comparison of Wet Limestone vs. Wellman-Lord/Allied	109
5	Power Plant Input Data - Des Moines Plant	145
6	Stack Gas Scrubbing System - Des Moines Plant	150
7	Power Plant Input Data - Maynard Plant	151
8	Stack Gas Scrubbing System - Maynard Plant	156
9	Power Plant Input Data - Muscatine Plant	157
10	Stack Gas Scrubbing System - Muscatine Plant	160
11	Power Plant Input Data - Riverside Plant	161
12	Stack Gas Scrubbing System - Riverside Plant	166
13	Power Plant Input Data - Burlington Plant	167
14	Stack Gas Scrubbing System - Burlington Plant	170
15	Power Plant Input Data - Kapp Plant	171
16	Stack Gas Scrubbing System - Kapp Plant	174
17	Power Plant Input Data - Prairie Creek Plant	175
18	Stack Gas Scrubbing System - Prairie Creek Plant	178
19	Power Plant Input Data - Sutherland Plant	179
20	Stack Gas Scrubbing System - Sutherland Plant	182
21	Equipment List - Wet Limestone System	186
22	Absorber-Venturi Standard Sizes	193
23	Wet Limestone Process - Scrubber Area Dimensions	194
24	Sludge Pond Size Sheet	196
25	Equipment List - Wellman-Lord/Allied Process	208
26	Wellman-Lord/Allied Process Standard Sizes	216
27	Equipment List - Coal Cleaning Plant	227

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I. INTRODUCTION

This report presents the results of a detailed study performed for the U. S. Environmental Protection Agency (Contract 68-02-1308, Task No. 3) and administered by the Iowa Geological Survey and the EPA. Close liaison and cooperation with the Iowa Department of Environmental Quality (IDEQ) and with the electric utility industry in Iowa were also essential aspects of this task.

The primary objective of this task was to study coal burning power plants in Iowa as a system and to evaluate various emission control strategies for this system which would minimize total operating costs while meeting selected SO_2 emission levels. To accomplish the objective it was necessary to determine the feasibility of building centralized facilities for physical cleaning of indigenous and "foreign" coals used in Iowa's coal-fired steam-electric generating plants. It was also necessary to determine the feasibility of stack gas scrubbing at some of the more problematic plants, as selected by the IDEQ. The impetus for the study was a need to determine optimal (minimum) costs of reducing power plant emissions of sulfur dioxide to or below regulation levels. In recent years increasingly more costly materials and services and scarcer clean fuels have made it difficult to economically meet stringent environmental constraints.

There are currently 35 power plants in the state which were designed to burn coal in at least one boiler per plant. Although many of them also consumed natural gas and fuel oil in past years, the assumption was made for this study that the Btu requirement in each plant capable of firing coal, was met exclusively with coal. The total generating capacity in the state is presently some 3093 mw (excluding that produced by two plants not designed for coal). Most of the plants are small, often with diminutive boilers which were added piecemeal over the years as power demands grew; rated capacities of the power plants range from 4.6 to 490.8 mw.

The plants selected for the stack-gas study are as follows:

- Des Moines Power Station No. 2, Des Moines
- Pella Plant, Pella
- Iowa State University Plant, Ames
- Maynard Plant, Waterloo
- Muscatine Plant, Muscatine
- Fair Plant, Montpelier
- Riverside Plant, Bettendorf
- Burlington Plant, Burlington
- Dubuque Plant, Dubuque
- Lansing Plant, Lansing
- Kapp Plant, Clinton
- Prairie Creek Station, Cedar Rapids
- Sixth Street Station, Cedar Rapids
- Sutherland Plant, Marshalltown

To obtain data and drawings and to permit comprehensive evaluation of each plant, the following actions were taken: (1) an introductory letter was sent by the Iowa Geological Survey to each of the utility home offices, explaining the purpose and conduct of the study; (2) questionnaires were mailed to the utilities, with more detailed information requested from the above listed plants; (3) Federal Power Commission Forms (FPC 67), detailing the plants' fuel consumption, operating parameters and effluent charateristics, were obtained from the EPA; and (4) visits were made to each of the plants above.* Additionally, photographs were taken at some of the sites when weather permitted.

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* The Lansing plant was not visited due to time limitations; however, adequate data and drawings were provided by the Interstate Power Company and the EPA.

The EPA Task Order specified that two flue-gas scrubbing methods be considered: the wet limestone system and a regenerable sorbent system which yields by-product elemental sulfur. Because the Wellman-Lord/Allied process has been applied at plant scale, it was selected for the second system. Some operating data are available for both methods; however, no attempt is made in this report to evaluate whether or not flue-gas scrubbing is proven technology. Instead the basic approach included application of available operating and design data to the power plants selected for consideration of equipment retrofit.

To accommodate a range of boiler sizes, a graduated set of standard scrubber modules was developed for both processes. Eight standard modules were designed from which an appropriate size and number could be selected for each application. For the wet limestone ststem, storage, preparation and handling equipment were sized and cost estimates were prepared for each plant.

Major use was made of computerized cost models in estimating capital and operating costs for both systems. Additionally, detailed estimates of capital costs of wet limestone systems were made by Kellogg's Estimating Department. Because of the nature of the estimates, the accuracy of vendor quotes, the lack of a completely definitive design, and other factors, the overall accuracy of the estimates is probably 30-35%, with the probability of underrun being very small.

Physical cleaning of coal was examined in this study as a possible alternative to flue-gas scrubbing. A subcontract was let to Gates Engineering, Inc., Beckley, West Virginia, to determine the availability, locations, costs, characteristics and washabilities of coals in Iowa, Illinois and Kentucky; the same parameters (except washability) were provided for Colorado, Wyoming and Montana coals. Also, capital and operating cost data were estimated for a typical 600 t/h (feed) coal-cleaning facility, and several likely locations were suggested for several centralized plants of like size.

Because of the large number of variables involved in determining the lowest system cost for reducing sulfur emissions in the state, it was necessary to devise a linear programming (LP) model capable of accommodating the many possible permutations and optimizing (minimizing) the system costs. Among these variables were transportation modes and costs, coal characteristics, coal costs and mine locations, power plant locations and fuel demands, possible cleaning plant locations and costs, and scrubbing equipment costs and characteristics. Much information comprising the data base was obtained from the coal-cleaning subcontract and was then used as input to solve the LP model. Using a matrix-generation routine and an optimization routine, the LP model is solved by computer to determine the optimal system costs for sulfur reduction.

The linear programming model, developed by Kellogg's Information Systems Department, proved to be a very useful tool. Once the model was perfected it was readily modified to accommodate a range of sulfur emission specifications, mine capacities, coal costs, transportation costs and other parametric constraints. Of course only one variable was allowed to change at a time so that the optimal solutions could be properly correlated. The resulting set of minimal system costs provided important inputs to the conclusions given in the next section.

The proposed sulfur dioxide emission regulation for the State of Iowa (on power plants not subject to Federal New-Source regulations is 6.0 pounds of SO_2 per million Btu of heat input (based on higher heating value of fuel) for coal-fired boilers. The present emission standard set by the Iowa Air Quality Commission (effective January 1, 1975) is 5 lb SO_2/MM Btu. It is worthy to note that this regulation is one of the least stringent constraints in the United States. Since it is possible that other SO_2 emission controls will be imposed, it was decided to use a range of sulfur control specifications for the linear program work. Thus we have been able to present comparative costs for optimal sulfur control at various specification levels. Sulfur dioxide emission levels used in his study included no control, 5.0, 3.1, and 1.2 lb SO_2/MM Btu.

A total of 18 power plants (2737 mw) were used in the linear computer program. At 100% generating capacity, these plants require about 35,000 t/d of coal. The use of a load factor of about 65-70% for these plants would more nearly approximate the actual Iowa coal demand. However, the conclusions reached regarding incremental system costs (in ¢/MM Btu) to meet any given specification would not change.

All costs used in the study - scrubbing system capital and operating costs, coal cleaning costs, coal pithead costs, ash and refuse disposal costs, coal storage/transfer cost, and rail and barge freight rates - are on a January, 1974 basis. The conclusions of the study are based on the assumptions made. The present unprecedented inflation rate leads to rapidly changing equipment, coal, and transportation costs. Therefore certain limitations exist when attempting to predict the optimal sulfur dioxide control strategy a few years hence.

Since this study was conducted for the State of Iowa, it follows that the conclusions apply only to that state due to Iowa's particular geographic location and power plant network.

It is recognized that the needs of other states for low sulfur western coal will make competition for this fuel very keen. However, the assumption was made for this study that at least 16,000 tpd will be available to Iowa utilities.

II. SUMMARY AND CONCLUSIONS

A. General Conclusions Pertaining to Coal as an Energy Source

- There is no question that coal is the most abundant fossil fuel energy source in the United States. Coal accounts for 87.1% of the mineral fuel reserves in the country. Oil and gas account for 8.1% and shale and others account for 4.8% (1, p. 29). The total coal reserves in the United States are estimated to be some 3,210 billion tons (1, p. 432) or 48.1% of the estimated total world reserves (1, p. 32). There is far more coal in this country than in any other country in the world.

- Of the total coal reserves in this country, about 71.3% is predicted to be bituminous, sub-bituminous, and anthracite (1, p. 432). If half of this coal can be considered recoverable, the usable reserves are approximately 1,144 billion tons (assuming no land use restrictions). In 1972, the steam-electric utility plants in the U.S. consumed fuel (coal, oil, and gas) at the rate equivalent to 634.9 MM tons of coal per year. At that rate of consumption, there is enough coal to last about 1,800 years. If the steam-electric utilities are allocated only 60% of the coal reserves (and assuming they burn coal exclusively), the reserves will last about 1,080 years. Finally, assuming a continued increase in the electric power demand, it is easy to see that there is enough coal to last for hundreds of years.

- The reserves of coal in the U.S. containing 1% sulfur or less are estimated to be about 65% of the total tonnage (based on a study done in 1966 by the Bureau of Mines - 1, p. 203). About 6% of the total reserves (containing 1% sulfur or less) lie in the eight major coal producing states (Alabama, Illinois, Indiana, Kentucky, Ohio, Pennsylvania, Virginia, and West Virginia). About 59% of the total reserves (containing 1% sulfur or less) are estimated to be in states which are not now major coal producers (principally, Colorado, Montana, New Mexico, North Dakota, and Wyoming). Hence it may be concluded that while there are abundant reserves of low sulfur coal in the country, drastic changes will be needed in the coal industry as well as in transportation to enable the steam-electric utility industry to use this coal.

B. General Conclusions Regarding the Supply of Coal for the State of Iowa

- The steam-electric power generating capacity in the State of Iowa (in 1972) is 3093 mw (9, p. 17). This power is generated at 35 plants having the ability to burn coal (some also can burn oil or gas). Two plants which burn only oil and gas and have a generating capacity of 19 mw total were not considered. The generating capacity in Iowa is fairly low - about 1% of the total in the United States (9, p. 53). The average load factor for all steam-electric power plants in Iowa in 1972 was 51% (9, p. 17). If the average load factor is assumed to increase to 60% in 1974 due to population and industrial growth as well as increased use of electrical equipment, and if the total energy requirement is met with coal, then the total coal requirement for the state will be about 8.66 MM tons/year (about 23,700 tons/day on a 365 day basis). Assumed are a heat rate of 12,000 Btu/kwh and an HHV of 11,260 Btu/lb.

- Total coal reserves in the State of Iowa are estimated to be 7,236 MM tons in seams thicker than 14 inches (2, p. 4). These reserves are located in 25 seams and are broken down as follows:

Thickness	MM Tons
14" - 28"	2,160
28" - 42"	2,252
+ 42"	2,824
Total	7,236

The tabulation shows that 5,076 MM tons exist in seams 28" or more in thickness which could be mined economically. Another source (1, p. 432) credits Iowa with known bituminous coal reserves of 6,519 MM tons with another 14,000 MM tons being estimated to exist in unmapped and unexplored areas. No matter which estimate is used, it is evident that there is enough coal in Iowa to meet the demand of the steam-electric utility industry for hundreds of years. However, the quality of Iowa coal is rather poor. The sulfur content ranges from 4-8%, the ash content from 12-23%, and the higher heating value (HHV) from 9,400-11,500 Btu/lb (2, p. 6). Therefore, owing to air pollution regulations, Iowa coal cannot be used unless one or more of the following control measures is put into effect:

- low sulfur coal blending
- coal cleaning
- stack gas scrubbing

- The logical states to choose as alternative suppliers of coal for Iowa are Illinois, Kentucky, Wyoming, Colorado, and Montana (as well as possibly Kansas and Oklahoma). Illinois has the largest known bituminous coal reserves in the United States and Kentucky has the third largest. However, these coals have intermediate sulfur contents (about 2-4% sulfur) and cannot be used exclusively to meet stringent air pollution regulations (2, p. 8). Wyoming, Colorado, and Montana are the best potential suppliers of low sulfur coal (< 1%) for the State of Iowa. The following table gives the breakdown of coal reserves of the states considered as suppliers (1, p. 432):

Coal Reserves of Potential Supply States (MM tons)

Overburden 0 - 3000 Ft. Thick

Resources Determined by Mapping and Exploration

	Bituminous Coal	Sub-bituminous Coal	Lignite	Anthracite	Total
Colorado	62,389	18,248	0	78	80,715
Illinois	139,756	0	0	0	139,756
Iowa	6,519	0	0	0	6,519
Kentucky	65,952	0	0	0	65,952
Montana	2,299	131,877	87,525	0	221,701
Wyoming	12,699	108,011	0	0	120,710

C. General Conclusions Reached When Comparing the Use of Low Sulfur Coal to Stack Gas Scrubbing to Meet an Emission Specification of 1.2 lb SO_2/MM Btu

- When low sulfur coals are located reasonably near the demand sites and when low cost unit train rates may be applied, the use of low sulfur coal appears to be superior to the use of stack gas scrubbing to meet emission regulations (particularly when the power plants are small, e.g., <250 mw, and difficult to retrofit with scrubbing facilities). This is the case in the State of Iowa where western coal is about 1000 miles away and the power plants are small. Simplified incremental system costs are shown below assuming equal coal pithead cost, Btu value, ash content, etc.

Basis: 250 MW Plant
Coal HHV = 10,000 Btu/lb
Incremental distance = 1000 miles

Use of Low Sulfur Coal	Stack Gas Scrubbing
$\frac{1000\ \text{Mi}\ (\$0.005/\text{T Mi})\ (100)}{20\ \text{MM Btu/ton}} = 25$¢/MM Btu	40-45¢/MM Btu

If transportation costs increase 60-80% (to $0.008-0.009/T-Mi) or if low sulfur western coals cost 15-20¢/MM Btu more than local coals, then the two cases would be essentially equal.

- When low sulfur coals are located at great distances (> 1500 miles) from the demand sites and when the power plants are large (> 500 mw) and relatively easy to retrofit with stack gas scrubbing facilities, the use of stack gas scrubbing appears to be superior. This is not the case in Iowa.

Basis: 1000 MW Plant
Coal HHV = 10,000 Btu/lb
Incremental Distance = 1500 miles

Use of Low Sulfur Coal	Stack Gas Scrubbing
$\frac{1500 \text{ Mi } (\$0.005/\text{T-Mi}) (100)}{20 \text{ MM Btu/ton}}$ = 37.5¢MM Btu	30-35¢/MM Btu

- If it should be determined that the use of either control measure (low sulfur fuel or stack gas scrubbing) would yield about the same incremental cost in ¢/MM Btu, then it probably would be advantageous to use stack gas scrubbing due to inflationary factors. About 40-50% of the costs associated with stack gas scrubbing will remain constant while incremental transportation costs (as well as pithead costs) for western coals will probably continue to rise.

The needs of other states for low sulfur coal along with finite mining, storage, loading, and shipping facilities will likely make competition for this source of "clean" fuel very keen. It is likely, in turn, that delivered costs of western coals will continue to increase.

D. Specific Conclusions Pertaining to the State of Iowa as Determined by the Linear Computer Program.

Three cases were considered for Iowa using the linear computer program.

Case 1: No limits are placed on any of the coal supplies.

Case 2: A limit of 16,000 t/d of western coal is imposed on the system. This is approximately the quantity of low sulfur coal required by the power plants for which it is not practical to use stack gas scrubbing in order to meet an emission specification of 1.2 lb SO_2/MM Btu. The other eight plants are then forced by the system constraints to use stack gas scrubbing to meet the most stringent regulation.

Case 3: Limits of 16,000 t/d of western coal and 7,000 t/d of Illinois coal are imposed on the system. These limits force the use of considerable quantities of Iowa coals (about 40% of the total state requirement).

Four different emission levels were considered for each case using the program.

20 lb SO_2/MM Btu:	This represents no control.
5 lb SO_2/MM Btu:	This will be the emission control level in Iowa as of January 1. 1975.
3.1 lb SO_2/MM Btu:	This level was arbitrarily chosen as being halfway between the actual emission level and the most stringent level.
1.2 lb SO_2/MM Btu:	This is the Federal emission control level for new coal-fired boilers.

For this study, the simplifying assumption was made that low sulfur western coals could be burned in existing Iowa boilers without modifying these boilers. In reality, it may or may not be necessary to modify the boilers and particulate emission control equipment depending on the properties of the particular western coal burned and on the design of the boilers. The modifications required, if any, may range from slight to extensive. It was not possible to quantify the effect of burning western coals in the existing power plants for this study. These boiler modification costs, if accounted for, would tend to shift the optimal cost solution in favor of stack gas scrubbing. Refer to Section II (Part G) for a discussion of the properties of western coals as they relate to use in existing boilers.

1. Case 1 - Unlimited western coal, unlimited Illinois coal

- The following table presents the incremental system costs for meeting various SO_2 emission specifications as well as the source of the coal for meeting the different specifications:

	Incr. System	Coal Used: % of Tonnage			
Spec: lb SO_2/MM Btu	Cost: ¢/MM Btu*	Iowa	Illinois	Western	Total
20 (No Control)	0.00	49.5	31.1	19.4	100.0
5	5.04	10.0	56.9	33.1	100.0
3.1	8.38	5.6	28.2	66.2	100.0
1.2	12.10	1.5	4.6	93.9	100.0

- As shown by the table, the incremental system costs rise about linearly as the regulations become more stringent. However the increase in cost is rather nominal (12.10¢/MM Btu), even when meeting the most stringent regulation (1.2 lb SO_2/MM Btu).

- In no instances are scrubbing facilities or coal cleaning plants installed. Instead, the more stringent regulations are met by blending in greater quantities of western coal.

- As shown in the table, whenever any emission regulation is imposed, the amount of Iowa coal used is rather small (dropping from 10% of the total at a 5 lb specification to 1.5% of the total at a 1.2 lb specification).

- The quantity of western coal used at the 1.2 lb specification is fairly large - about 3 unit trains/day (note that a unit train carries about 10,000 tons).

- Western coal would need to increase in cost by about $6.50/ton in order to obtain equal costs for Cases 1 and 2 at the 1.2 lb specification. It would need to increase in cost by about $7.60/ton to obtain equal costs for Cases 1 and 3 at this specification. These increases in cost may result from increased coal pithead cost, increased transportation cost, or a combination of the two.

* Includes all incremental coal, transportation, treatment, storage and disposal costs to meet the specified emission level.

2. Case 2 - 16,000 T/D limit on western coal, unlimited Illinois coal

- The following table summarizes this case:

Spec: lb SO_2/MM Btu	Incr. System Cost: ¢/MM Btu	Coal Used: % of Tonnage Iowa	Illinois	Western	Total
20 (No Control)	0.00	49.5	31.1	19.4	100.0
5	5.04	10.0	56.9	33.1	100.0
3.1	9.66	20.6	35.5	43.9	100.0
1.2	26.21	11.9	42.5	45.6	100.0

- This case is identical to the previous case (Case 1) with no control or with a 5.0 lb specification. The incremental costs are somewhat higher at the 3.1 lb specification (about 1.3¢/MM Btu) because the limitation of western coal forces a cleaning plant to be installed (capacity = 7,489 t/d; location - Leon, Iowa).

- At the 1.2 lb specification, a drastic increase in incremental system cost occurs. With this regulation, scrubbing facilities are installed at the eight plants which were considered possible candidates for scrubbing. (Note that 16,000 t/d of western coal is that quantity which is required in order for the other ten plants to meet the 1.2 lb specification). No coal cleaning plants are installed. The incremental system cost is 26.21¢/MM Btu over no control or about 14¢/MM Btu over Case 1 which has unlimited western coal.

3. Case 3 - 16,000 T/D limit on western coal
   7,000 T/D limit on Illinois coal

- The following table summarizes this case:

Spec: lb SO_2/MM Btu	Incr. System Cost: ¢/MM Btu	Coal Used: % of Tonnage Iowa	Illinois	Western	Total
20 (No Control)	1.03	59.9	18.7	21.4	100.0
5	8.02	38.6	18.7	42.7	100.0
3.1	12.24	40.4	18.1	41.5	100.0
1.2	28.58	38.7	18.7	42.6	100.0

- In this case the Illinois coal was limited to about 20% of the total in order to observe how the use of increased quantities of Iowa coals influenced system costs. Under the three control conditions (specifications of 5, 3.1 and 1.2), the total Iowa coal used was about 14,000-15,000 t/d or about 40% of the total. Based on the assumptions made, the incremental system costs for this case (Case 3) rose by about 2.5-3¢/MM Btu over the costs for Case 2. The pithead costs for the Iowa coals would have to be lowered by about $1.50/ton in order to obtain costs equal to Case 2. Also, the costs for no control increased by 1.03¢/MM Btu over Cases 1 and 2 because of the increased use of Iowa coal.

- Cleaning plants are installed under all three control conditions due to the high sulfur content of the Iowa coals.

Spec: lb SO_2/MM Btu	Cleaning Plant Size: T/D	Location
5	7,200	MB*(Mine at
3.1	14,398	MB Leon
1.2	7,200	MB Iowa)

- Stack gas scrubbing is installed on the eight plants (previously deemed possible candidates) only for the most stringent regulation (1.2 lb SO_2/MM Btu). Note again that the use of stack gas scrubbing causes a rather sharp increase in incremental system costs.

E. Conclusions Regarding Coal Cleaning

- Coal cleaning (by heavy media washing) is a viable method of sulfur removal for coals which have a relatively high pyritic sulfur (FeS_2) content. About 1/3 to 1/2 of the sulfur originally present can be removed. No organic sulfur can be removed by this process. A sizable reduction in ash content (about 50%) also is realized by this process. However, about 12-16% of the Btu content of the coal is lost (at 80% total coal recovery).

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* Refer to Section VII for explanation of location codes.

The following table lists properties of raw and cleaned coals (80% coal recovery):

Mine	Location	Raw Coal Properties (As Received) % Moisture	% Ash	% Sulfur	Btu/lb
MA	Frederick, Iowa	11.2	14.2	5.9	10,038
MB	Leon, Iowa	18.0	12.8	4.3	9,676
MC	Ogden, Iowa	13.4	13.2	6.9	10,184
MD	Marion, Illinois	7.0	14.9	3.1	11,951
ME	Madisonville, Ky.	8.3	14.8	4.1	11,801

Mine	Location	% Moisture	% Ash	Clean Coal Properties % Sulfur	Btu/lb	% HHV Recovery
MA	Frederick, Iowa	11.2	7.9	3.5	11,033	87.9
MB	Leon, Iowa	18.0	7.0	1.9	10,650	88.1
MC	Ogden, Iowa	13.4	7.5	4.5	11,166	87.7
MD	Marion, Illinois	9.0	7.0	2.0	12,505	83.7
ME	Madisonville, Ky.	8.3	7.2	2.7	12,340	83.6

- An examination of the table indicates that only a modest reduction in sulfur content normally can be achieved utilizing coal cleaning. Therefore, this process appears to be promising only when an intermediate SO_2 emission regulation is in effect (i. e., 3.1 to 5.0 lb SO_2/MM Btu). Obviously, cleaning of these coals will not prove to be adequate to meet the most stringent regulation (1.2 lb SO_2/MM Btu). In some cases, a combination of coal cleaning and the use of low sulfur coal will prove to be the logical choice to meet a given specification.

- An 80% coal recovery level was chosen for all coals after cleaning as this is approximately the optimum. An examination of the graph (2, p. 16) of sulfur content vs. percent recovery for Iowa coals reveals that the largest drop in sulfur content occurs from 100 to 80% recovery. There is very little decrease in sulfur content as recovery drops from 80 to 60%.

- The operating cost of coal cleaning (for plants in the size range of 600 t/h raw coal feed) is about $1.90/ton feed coal. The capital investment cost for a 600 t/h plant (which operates 2 shifts/day for 220-260 days per year) is broken down as follows (2, p. 13).

	Capital Investment: $
Raw coal unloading and storage	1,471,000
Preparation plant	3,841,000
Clean coal handling	1,437,000
Site preparation, roads, etc.	590,000
Refuse handling	360,000
Total	7,699,000

This is equivalent to a unit investment of about $12,800/t/h for plants in the 600 t/h size range.

- Refuse disposal from a cleaning plant is expected to add about $0.31/ton of refuse to the operating cost (2, p. 21). The operating cost for intermediate storage of coal (whether at a cleaning plant or at a transfer point) is expected to be about $0.30/ton of raw coal (2, p. 21).

- Refuse from a cleaning plant may be disposed of by several alternative methods. The means of transporting the refuse from the plant is dependent on factors such as terrain, availability of disposal areas, and quantity of material to be disposed of. The most common methods used to transport the refuse are trucking, belt conveyors, and aerial tramways.

At the disposal site, earthmoving equipment must be available to move and compact the refuse. Depending on state requirements, when filling of an area is completed, it may be necessary to cover the refuse with a layer of soil and plant the area with vegetation.

During storage of refuse, drainage facilities must be provided to divert runoff water from adjacent areas away from the refuse storage. Also, drainage ditches must be installed to collect runoff water from the refuse area and send it to a pond. If this water is acidic, provisions for treatment will be needed before the water can be discharged into streams (2, pp. 17, 18).

- The following hypothetical case is a summary of the incremental cost to a power plant to clean a relatively high sulfur coal to a level sufficient to meet a specification of 5.0 lb SO_2/MM Btu.

	$/ton
Coal Storage	0.30
Coal Cleaning	1.90
Refuse Disposal	0.06
	2.26

	% Sulfur	HHV:Btu/lb
Raw Coal	4.0	10,000
Clean Coal	2.7	10,800

% Sulfur Removal = 46

% HHV Lost = 14

SO_2 Emission = 5 lb/MM Btu

Incremental cost to power plant $= \frac{2.26 \times 100}{0.86 \times 20 \text{ MM}} = 13.1$¢/MM Btu

If, instead of cleaning, a sufficient quantity of low sulfur coal (0.9% S) which must be transported 1,000 miles, is blended with the 4.0% coal to meet a specification of 5.0 lb SO_2/MM Btu, the following cost results (assuming equal coal pithead cost, Btu value, ash content, etc.):

	% Sulfur	HHV	Incr. Distances: Miles
High Sulfur Coal	4.0	10,000	0
Low Sulfur Coal	0.9	10,000	1,000

Weight fraction of high sulfur coal = 0.516
Weight fraction of low sulfur coal = 0.484
Unit train freight rate = $0.005/T-mile

$$\text{Incremental cost to power plant} = \frac{0.484\ (1000)\ (0.005)\ (100)}{20\ \text{MM}} = 12.1¢/\text{MM Btu}$$

Therefore, it can be seen that the choice between coal cleaning and blending low sulfur coals is a close one. It depends primarily on the following factors:

- Actual incremental distance the low sulfur coal must be transported and the freight rate
- Pithead costs of the low vs. the high sulfur coal
- Actual ash, moisture, Btu, and sulfur contents of the two coals
- Degree of sulfur removal attained when cleaning the high sulfur coal
- Rate at which new low sulfur coal supplies can be made available

F. Conclusions Regarding Stack Gas Scrubbing

1. Capital Investment

- The following table summarizes the approximate capital investment required to install wet limestone scrubbing at the eight power plants in Iowa selected as potential candidates for scrubbing:

Plant	MW	Capital Investment: $	$/KW
Des Moines	325	24,300,000	74.60
Maynard	107	16,200,000	151.10
Muscatine	117	11,300,000	96.90
Riverside	222	18,900,000	85.00
Burlington	212	14,300,000	67.40
Kapp	237	15,900,000	67.00
Prairie Creek	245	19,600,000	80.10
Sutherland	157	17,000,000	108.30
Total	1622	137,500,000	84.80 Average

The above figures assume that a thickener and small pond are provided for sludge. If a large pond was installed at six of the eight plants where space may be available (Des Moines, Muscatine, Burlington, Kapp, Prairie Creek and Sutherland), the investment cost would increase by about $7-12/kw depending on sulfur content of the coal.

- Of the thirteen plants for which detailed capital cost estimates were prepared, five were dismissed from consideration due to their small size and hence burdensome costs (or due to space limitations). These plants are Pella, Iowa State University, Fair, Dubuque, and Lansing. The average cost for limestone scrubbing for these five plants is $171.10/kw or about double that for the other eight plants. No estimate was prepared for the Sixth Street Station due to the unusually limited space at the site.

- Estimates for the Wellman-Lord/Allied scrubbing system costs were made using the M. W. Kellogg computerized cost model (3, pp. 110-129). They were made assuming the same degree of difficulty of retrofitting this process as would be encountered with the Wet Limestone process. The capital estimates are shown below:

Plant	MW	Capital Investment:$	$/KW
Des Moines	325	36,400,000	112.00
Maynard	107	18,400,000	172.50
Muscatine	117	14,900,000	127.10
Riverside	222	24,800,000	111.60
Burlington	212	18,800,000	88.50
Kapp	237	20,700,000	87.50
Prairie Creek	245	23,300,000	94.90
Sutherland	157	20,500,000	130.50
Total	1622	177,800,000	109.60 Average

The figures shown above indicate that in every case the Wellman-Lord/Allied process is more costly than the Wet Limestone process (by an average value of about $24-25/kw). Wellman-Lord/Allied scrubbing systems also would not be feasible at the six plants previously ruled out for Wet Limestone scrubbing for the same reasons.

2. Capital and Operating Cost

- Computerized cost models also were used to calculate capital and operating costs for both the Wet Limestone process (3, pp. 83-98) and the Wellman-Lord/Allied process. The basic input data for the programs are listed below:

HR = 11,000 Btu/KWH (Plant average heat rate)
HHV= 10,000 Btu/lb (Coal higher heating value)

RBmax = 1.7 (Retrofit difficulty factors selected
RBase = 3.5 to best match detailed cost estimates)
F = 1.52 (Location factor)
LF = 0.70 (Load factor)
CSL = $1.50/T (Wet Limestone process sludge disposal cost)

The average capital investment predicted by the model for the two processes (for the eight plants in Iowa) is as follows:

Wet Limestone	$ 86.40/KW
Wellman-Lord/Allied	109.80/KW

- Operating costs for the two processes are shown below:

	¢/MM Btu Input					
Plant Gen:	2% Sulfur		4% Sulfur		6% Sulfur	
Cap: MW	W. L.	W-L/A	W.L.	W-L/A	W.L.	W-L/A
250	34.3	37.2	40.5	49.2	46.8	61.3
500	32.7	33.5	38.9	45.3	45.0	57.2

  - Based on the assumptions made, the Wet Limestone process is less expensive to operate than the Wellman-Lord/Allied process in all cases.

  - When processing flue gas from boilers burning very low sulfur coal (1-2 % S), the processes are about equal in cost.

  - As expected, as plant size increases, the operating cost in ¢/MM Btu decreases.

  - The Wellman-Lord/Allied process is more sensitive to the sulfur content in the coal than is the Wet Limestone process. For a 250 mw power plant, the increased operating cost for each 1% sulfur increase is shown below:

Wet Limestone	3.12¢/MM Btu
Wellman-Lord/Allied	6.02¢/MM Btu

- The sludge disposal cost for the Wet Limestone process which will bring its operating cost up to a figure equal to that of the Wellman-Lord/Allied process is variable and depends on the sulfur content of the coal. For a 500 mw plant burning low sulfur coal (~ 2.5% S) this cost is about $2.44/ton of wet sludge. For the same size plant burning high sulfur coal (~5.% S), this cost is about $3.44/ton.

- The higher operating costs for the Wellman-Lord/Allied process (using high sulfur coals) can be explained solely by capital charges on a considerably greater investment. There is much more equipment associated with this process due to its complexity.

- The somewhat higher variable costs for chemicals, utilities, and principally waste disposal for the Wet Limestone process are offset by lower labor charges.

- For the Wet Limestone process, economics indicate that if sludge disposal costs rise above about $1.50/T, then the installation of a large pond would be indicated in order to limit disposal costs.

● Sludge disposal for the Wet Limestone process presents a major problem. The sludge is composed mainly of $CaSO_4 \cdot 2H_2O$, $CaSO_3 \cdot 1/2H_2O$, unreacted $CaCO_3$, and fly ash. The quantity produced (at 40% solids) is about 15 tons per ton of sulfur removed from the flue gas (4, p. 7). The size of a pond to hold 20 years of sludge production is quite large. For example, a 250 mw power plant burning 5.0% sulfur coal would require a sludge pond 120 acres in area x 50 feet deep (4, p. 79).

● Solids disposal does not present as great a problem for the Wellman-Lord/Allied process. Sulfur produced is assumed to have a credit (of $10/LT). This may be an oversimplification if the sulfur supply-demand situation is studied. In 1985, the North American demand for sulfur will probably reach about 17.5 MM tons while the supply from traditional sources (Frasch process, gas and oil desulfurization, and smelter acid) will be about 22 MM tons. Therefore it is obvious that the supply from existing sources is more than adequate to meet the demand from traditional sulfur consuming industries in 1985. If (by 1985) the utility industry was consuming 500 MM tons/year of coal containing 3% sulfur then an additional 15 MM tons/year of sulfur would be potentially available. Clearly this would tend to lead to a considerable oversupply of sulfur. However there are some potential new uses for sulfur which may help to alleviate the problem. Some of these are (17, pp. 239-243):

- Addition of sulfur to asphalt for use as a paving material
- Sulfur use in concrete
- Sulfur use as a bonding material
- Sulfur use as a coating material

A small quantity of purge solids also is formed in the Wellman-Lord/Allied process. These solids (consisting mostly of sodium sulfate and sodium thiosulfate) are produced at the rate of about 0.30 tons/ton of sulfur removed from the flue gas (3, p. 121).

3. Stack Gas Scrubbing Evaluated in the Linear Program

- Since the Wet Limestone process appears to be less costly then the Wellman-Lord/Allied process, its operating costs were incorporated into the linear computer program. Two segments of the Wet Limestone process operating cost were input into the program:

- The first is dependent on plant size

- The second is dependent on sulfur content of the coal

- The linear program could be modified to accommodate operating costs for any other scrubbing process.

- As discussed previously, stack gas scrubbing does not compare favorably (in Iowa) with the use of low sulfur coal and/or coal cleaning.

  - At the 1.2 lb SO_2/MM Btu specification, no stack gas scrubbing is used if unlimited low sulfur coal is available. If low sulfur coal is limited, stack gas scrubbing is used in eight plants.

  - At the intermediate specifications (3.1 and 5.0 lb SO_2/MM Btu), no stack gas scrubbing is used. Emission standards are met by using low sulfur coal and/or coal cleaning.

G. Conclusions Pertaining to the Use of Western Coals In Existing Boilers

1. General

- The conclusions reached in this study point to the use of about 33 to 94% western coals in Iowa boilers to meet varying SO_2 emission regulations. The use of these western coals in boilers and in pollution control devices (electrostatic precipitators) designed for indigenous and midwestern coals may pose operational problems which will have to be dealt with on an individual case basis. Of primary importance are ash characteristics which determine the degree of slagging and fouling which will occur in the boiler, the bulk resistivity of fly ash passing through existing electrostatic precipitator installations, and the abrasiveness of the coal.

2. Average Properties of Western Sub-bituminous Coals

- The following table gives the range of properties of the western sub-bituminous coals used in this study.

% Moisture	12.4 - 25.5
% Ash	4.2 - 10.0
% Sulfur	0.3 - 0.9
HHV (Btu/lb)	8790 - 11,460
Grindability (Hardgrove)	45 - 53

- In general, the western sub-bituminous coals are low in sulfur (below 1%); they are relatively high in moisture and, therefore, relatively low in heating value; they are high in volatile matter and have good ignition characteristics.

Of main concern to the boiler designers however, are the ash characteristics. In this respect Western coals run the full spectrum.

3. Ash Slagging

- Ash slagging refers to the ash deposits that form on surfaces in the furnace exposed to radiant heat (10, p. 2). The ash fusion temperature of a given coal provides a rough indication of the potential furnace wall slagging problems which may occur. Generally boilers which use coals with high ash fusion temperatures will remain dry with little or no deposit on the furnace wall. Slagging is usually meant to be the physical transport of molten or sticky ash particles and the subsequent formation of dense hard deposits on the radiant tubes (11, p. 3). Most coals have low to intermediate ash fusion temperatures; hence boiler designers must rely largely on slag viscosity characteristics of lignite type ash to predict slagging tendencies in boilers (18, p. 9). Coals with low ash viscosity characteristics tend to cause excessive slagging (18, p. 3). If the information is available, the viscosity of the coal ash slag is used as a guide in furnace design of a steam generator. When the viscosity of the ash is not known, however, it has been necessary to derive slagging indices based on ash analysis and furnace observation. One such slagging index (R_S) has been developed which divides the slagging characteristics of coal into four different categories as shown below (11, p. 11).

Slagging Type	Slagging Index: R_S
Low	Less than 0.6
Medium	0.6 - 2.0
High	2.0 - 2.6
Severe	Greater than 2.6

Based on the relative slagging index the furnace design may be modified to consider such items as burner input vs. furnace size, burner clearances, furnace exit gas temperatures, and the number and location of furnace wall blowers for the most effective removal of slag (11, pp. 11-12).

4. Ash Fouling

- Ash Fouling refers to bonded deposits that form at high temperatures on convection tube banks, especially the superheater and reheater which are not exposed to direct radiant heat from the furnace (11, p. 2). The high temperature bonded deposits are generally caused by volatilization of elements from the ash and selective condensation and deposition upon the convection tube surfaces as well as by impaction of ash on the tubes. The amount of ash in the coal frequently has little influence on ash fouling. More important is the behavior of the ash minerals when they are subjected to high temperatures during combustion of the coal (11, p. 4).
- The first constituents identified as contributing to deposit strength are the alkali metals, sodium and potassium (10, p. 2). Generally the sodium oxide and calcium sulfate content of the ash is used to predict fouling tendencies in the convection passes (18, p. 6).
- A fouling index R_F has been devised dividing coal into four categories (11, p. 12).

Fouling Type	Fouling Index: R_F
Low	Less than 0.2
Medium	0.2 - 0.5
High	0.5 - 1.0
Severe	Greater than 1.0

- Some of the boiler design parameters which may be changed to mitigate the relative fouling tendency of the coal are the flue gas temperature, back-spacing and side-spacing of tubes, slope of superheater and reheater floor and clearances under pendant sections, number and location of soot blowers, cleaning radius of soot blowers, and tube bank depths. For example, if it is expected that the coal to be fired will produce hard massive deposits (R_F= 1.0 or higher) the pendant superheater sections are designed to permit easy deposit removal. Lateral tube spacing is increased, tube bank depth is decreased, and the banks are located in cooler gas temperature zones. A greater number of high capacity soot blowers will be required (11, p. 13).

5. Relative Abrasiveness of Sub-bituminuous Coal

- An important characteristic of a coal is its relative abrasiveness. This property may affect the life of grinding equipment (pulverizers) by a factor of 5-10 to 1. Abrasiveness is a separate characteristic of coal apart from the grindability. The abrasiveness of a coal depends largely upon the amount of quartz or other hard materials associated with the impurities, while grindability is determined primarily by the structure of the organic materials. In abrasiveness also, the western sub-bituminuous coals run the full spectrum from high to low (18, p. 3).

6. Electrostatic Precipitator Performance

- Ironically the low sulfur content of western coals which makes them so attractive may cause problems with particulate collection in the electrostatic precipitators. Two of the important parameters in determining the efficiency of an electrostatic precipitator are the residence time and the resistivity of the fly ash. Performance drops off with increased resistivity (due to lower sulfur content) and with decreased residence time.

- One approach used to improve efficiency is to make the electrostatic precipitators larger, hence decreasing the velocity which will compensate for the change in resistivity. This approach is expensive, however, because the electrostatic precipitators must be increased in size. It would be very impractical for existing units which are already in service.

- A second approach used is to locate the electrostatic precipitator in the hot gas zone upstream of the air preheater (where the resistivity of the fly ash is lower) thereby regaining the fly ash removal efficiency. Using this technique means treating a greater gas volume and makes the electrostatic precipitators larger and more expensive (10, p. 3). This approach is also impractical for existing cold side units.

- The third approach used to restore electrostatic precipitator efficiency is the conditioning of the flue gas with a small quantity (15-20 ppm) of SO_3 to lower the resistivity of the fly ash. When sulfur content in the coal is low the resistivity of the fly ash particles is high (at normal air heater outlet temperatures) and it is difficult for them to accept a charge and be attracted to a plate in the electrostatic precipitator. Conditioning the gas produces a lower resistivity of the fly ash particles and restores the electrostatic precipitator efficiency (13, pp. 50-53). This is the recommended approach for the Iowa power plants when burning low sulfur western coal.

III. OVERALL SYSTEM EVALUATION

The State of Iowa currently has some 35 power plants which burn coal with a total installed generating capacity of 3093 mw. Though many of the boilers in these plants have previously burned some natural gas and fuel oil, the assumption was made for this study that the energy requirement for each plant will be met exclusively with coal. Indeed, the projected use of coal in 1975 will total 79.1% of the state's utility fuel requirement and in 1980 will total 89.0% (1, p. 326).

Coal used in Iowa utilities comes from a number of states (Iowa, Illinois, Kentucky, Kansas, Oklahoma, Wyoming, and others). There are many mines in each state which can supply coal. In addition, there are many different methods (and different costs) of transporting the coal from the mines to the power plants (truck, rail, unit train and barge or some combination of these). Also, the coal may travel over different routes. The purchased price of each coal varies as does its properties (% ash, % sulfur, HHV, and % moisture). The cleaned properties of each coal also vary.

When coal is burned in utility power plants, the sulfur originally in the coal (whether present as pyritic sulfur, organic sulfur, or sulfate) is converted to SO_2 and SO_3 (100% conversion to SO_2 was assumed in this study) which then flows out of the stack in the flue gas. A number of different maximum emission levels of SO_2 (lb SO_2/MM Btu input) are being considered. The least stringent regulation, of course, would be no control and the most stringent regulation would be the Federal new-source regulation of 1.2 lb SO_2/MM Btu. There are also some intermediate regulations being considered.

How does a utility control the amount of SO_2 being emitted to meet a given regulation? Three methods or some combination of them were chosen in this study:

- the use of low sulfur coal
- coal cleaning
- stack gas scrubbing

To further compound the problem, the number, size and locations of the cleaning plants and scrubbing systems can vary.

To evaluate a system of such complexity, M. W. Kellogg devised a linear computer program. The program minimizes the overall system cost while delivering the required amount of coal to each power plant and while meeting any one of a number of different SO_2 emission specifications.

A. Basic Assumptions Made for the System to Use in the Linear Computer Program

1. Power Plants Considered

In order to limit the size of the problem, it was necessary to limit the number of power plants considered in this study. A total of eighteen power plants having an installed generating capacity of 2737 mw (88.5% of the total) was used. The following table lists these power plants, their generating capacity, and their energy requirements in MM Btu/D.

Location Code* Class DL	Plant Location	MW	MM Btu/D**
DA	Ames (Ames Municipal Plant)	60	18,684
DB	Ames (Iowa State University)	25***	12,994
DC	Montpelier	63	17,726
DD	Lansing	64	20,023
DE	Dubuque	74	24,504
DF	Clinton	237	59,525
DG	Cedar Rapids (Prairie Creek)	245	64,862
DH	Cedar Rapids (6th Street)	92	64,937
DI	Marshalltown	157	43,219

* Refer to Section VII of this report

Class DL	Plant Location	MW	MM Btu/D**
DJ	Bettendorf	222	67,512
DK	Council Bluffs	131	33,461
DL	Des Moines	325	87,017
DM	Waterloo	107	31,570
DN	Salix	491	115,682
DO	Eddyville	71	25,608
DP	Burlington	212	51,307
DQ	Muscatine	117	31,488
DR	Pella	44	18,259
Total		2737	788,378

** @ 100% generating capacity (a 65-70% load factor for these plants would more nearly approximate the actual Iowa coal requirement)

*** Included because of high heat rate due to exporting heating steam

Generally speaking, power plants with a generating capacity of about 40 mw or less were eliminated from consideration in this study. Some seventeen plants comprising about half of the total number of plants in the state but only about 11.5% of the generating capacity were thus eliminated. Conclusions reached in the study however (which include coal cleaning or low sulfur coal blending), may be extended to include the small power plants.

2. Coal Mine Selection

The following tables list the eight coal mines which were selected for this study. The tables also list the mined coal properties, costs, mine capacities, and clean coal properties.

Location Code		Raw Coal Properties				
Class ML	Location	% Ash	% Sulfur	Btu/lb	Cost: $/T	Mine Capacity: MT/D
MA	Frederick, Iowa	14.2	5.9	10,038	6.25	VARIES
MB	Leon, Iowa	12.8	4.3	9,676	6.25	
MC	Ogden, Iowa	13.2	6.9	10,184	6.25	
MD	Marion, Ill.	14.9	3.1	11,951	6.70	
ME	Madisonville, Ky.	14.8	4.1	11,801	6.70	
MF	Hanna, Wy.	8.4	0.9	10,506	4.20	
MG	Craig, Col.	4.2	0.3	11,460	5.00	
MH	Colstrip, Mont.	10.0	0.8	8,790	3.60	

Cleaned Coal Properties*

Location Code Class ML	% Ash	% Sulfur	Btu/lb	Loss : %
MA	7.9	3.5	11,033	20.0
MB	7.0	1.9	10,650	20.0
MC	7.5	4.5	11,166	20.0
MD	7.0	2.0	12,505	20.0
ME	7.2	2.7	12,340	20.0

Selection of the coal mines to provide coal for the Iowa Utility Industry was based primarily on the report submitted by the Gates Engineering Company (2, pp. 7-9). Ten potential mines were presented in the report for the State of Iowa. From this group three were selected as being representative of the Iowa coal supply (2, p. 14). For the State of Illinois the average properties of the No. 5 and No. 6 seams from Marion, Illinois were used in the study (2, p. 8).

The Kentucky coal used in the study is from Madisonville, Kentucky. The average properties of the No. 6, No. 9, No. 11, and No. 12 seams from Madisonville were used (2, p. 8). A number of potential mine sites were given in the Gates report, Appendix C, in Wyoming, Colorado, and Montana. From this list one mine site considered to be representative was selected for each state. The three choices were Hanna, Wyoming; Craig, Colorado; and Colstrip, Montana.

The coal prices (FOB mine) also were furnished in the Gates report. In Iowa, Illinois, and Kentucky the coal was assumed to be 40% strip mined and 60% deep mined. The western coals were considered to be 100% strip mined. Each ton of strip mined coal has a 70¢ transfer charge added to transport the coal from the mine to the rail site. Coal prices are given in the Gates report (2, p. 1).

* Coal properties which can be achieved by a coal cleaning plant with 80 weight % recovery.

The following calculations show how the coal pithead costs were computed.

% strip mined (strip mine cost) + % deep mined (deep mine cost) + % strip mined (strip mine transfer charge) = total

Iowa Coal

0.4 (4.85) + 0.6 (6.70) + 0.4 (0.70. = $6.24 (Use $6.25/T)

Illinois Coal & Western Kentucky Coal

0.4 (5.25) + 0.6 (7.20) + 0.4 (0.70) = $6.70/T

Wyoming Coal

3.50 + 0.70 = $4.20/T

Colorado Coal

$\frac{(3.90 + 4.70)}{2} = 4.30 \quad 4.30 + 0.70 = \$5.00/\mathrm{T}$

Montana Coal

$\frac{8790}{10506}(3.50) = 2.93 \quad 2.93 + 0.70 = \$3.63/\mathrm{T}$ (Use $3.60/T)

It was assumed that the five high sulfur coals used in the study could all be cleaned to the 80% recovery level. This recovery level is shown to be about optimum from the Gates report (2, pp. 14-16) for the Iowa coals. The same recovery level of 80% also was chosen for the Illinois and Kentucky coals. Note that no cleaning was permitted for the western coals since these fuels are already very low in sulfur content and fairly low in ash content.

3. Potential Other Possible Transfer Points (in addition to the mines and power plants)

The following is a list of other possible transfer points:

Class OL	
PA	Paducah, Kentucky
PB	Gorham, Illinois

Paducah, Kentucky is located on the Ohio River, 85 miles by rail from Madisonville, Kentucky. A logical method of shipment would be by standard rail from Madisonville to Paducah and then by barge on the Ohio and Mississippi Rivers to the power plants. Gorham, Illinois was chosen as a possible transfer point because it is the closest point on the river from the Marion, Illinois mine. Again a logical shipping method would be to ship coal by standard rail from Marion, Illinois to Gorham and then by barge on the Mississippi River to the Iowa power plants.

4. Potential Scrubbing Locations

The following plants were chosen as potential sites for scrubbing facilities:

Class SL	Plant Location
DF	Clinton
DG	Cedar Rapids (Prairie Creek)
DI	Marshalltown
DJ	Bettendorf
DL	Des Moines
DM	Waterloo
DP	Burlington
DQ	Muscatine

Ten of the eighteen power plants used in the study were not considered for stack gas scrubbing due to either the small generating capacity of the plant, overcrowded conditions existing at the plant, or previous committments for low sulfur fuel by the plant.

5. Potential Cleaning Locations

The following is a list of possible coal cleaning plant locations chosen in the Iowa study:

Class CL	Location
DN	Salix, Iowa
DP	Burlington, Iowa
MA	Frederick, Iowa
MB	Leon, Iowa
MC	Ogden, Iowa
MD	Marion, Illinois
PA	Paducah, Kentucky
PB	Gorham, Illinois

It was necessary to reduce the number of possible cleaning locations in order to greatly minimize the number of calculations to be performed by the computer. The logical cleaning plant locations are at the mines since there is a 20% material loss at the cleaning plant resulting in considerably lower freight rates from the mines to the power plants. Four other possible cleaning locations (DN, DP, PA, and PB) were also selected.

6. Summary of Loading/Unloading Facilities

All power plants, mines and the two other locations were assumed to have standard railroad facilities. In addition, unit train facilities were assumed to be present at DN, DP, MD, ME, MF, MG, and MH. Barge loading/unloading facilities were assumed to be present at the seven Iowa power plants located on the Mississippi River (DC, DD, DE, DF, DJ, DP, and DQ). Also, barge loading facilities were assumed to be present at PA and PB.

7. Specifications

The following list includes the four specifications that the program was run for:

Table Specification

1	20.0	lb SO_2/MM Btu (No emission control)
2	5.0	lb SO_2/MM Btu
3	3.1	lb SO_2/MM Btu
4	1.2	lb SO_2/MM Btu

Note that the model can be easily adjusted to run any other specification as long as it is uniform statewide or systemwide.

8. Summary of Economic Factors

	Rate	Basis
Standard Rail	$0.028/T-M	Iowa Util. Avg. Rate
Unit Train	$0.005/T-M	(1, p. 435)*
Barge	$0.006/T-M	(2, p. 21)
Ash Disposal at Pwr. Plant	$1.00/T	Iowa Utilities
Refuse Disposal at Clng. Plant	$0.31/T	(2, p. 21)
Storage/Transfer Cost	$0.30/T	(2, p. 21)**
Cleaning Plant Oper. Cost	$1.90/T	(2, p. 13)***

*Supplemented by information from Union Pacific Railroad

**Applies to any coal shipment which goes through an intermediate point (either a transfer point or a cleaning plant)

***Adjusted to include profit, depreciation, and interest.

9. Distances by Rail

The distances between all points are tabulated in the Table RRDIST which forms a symmetric matrix half of which is entered as a triangular table. The 1973 Railroad Atlas was used to compute the minimum distances between all points (8). In many cases, calculating the minimum distance between two points meant transferring from railroad tracks owned by one railroad company to tracks owned by another company. This operation was assumed to present no problem for the study.

10. Distances by River

A separate table (Table RIVERD) was supplied to give the river mileages between all points located on the Mississippi and Ohio rivers. This table is to be used in calculating barge transportation costs. The points included in this table are power plants DC, DD, DE, DF, DJ, DP, and DQ and other locations, PA, and PB.

11. Cost of Washing and Scrubbing

As indicated above, the coal cleaning plant operating cost used in this study is $1.90/ton of feed coal. The minimum cleaning plant size used is one capable of processing 7200 t/d of feed coal. The cost of stack gas scrubbing (using the Wet Limestone process) is made up of two parts. The first is the non-linear cost which is related to plant size; the second is the linear cost related to the sulfur content in the feed coal. These costs are broken down more fully in Sections VI and VII. The minimum size scrubbing facility considered is one which would be applicable for a 50 mw boiler.

B. Linear Computer Program Results

The following tables summarize the results for the three cases studied for Iowa. The following items are shown in the tables for each of the sulfur dioxide emission levels (20, 5, 3.1, and 1.2 lb/MM Btu):

- All of the components which comprises the total system cost (coal pithead cost, freight cost, ash disposal cost, scrubbing cost, coal washing cost, refuse disposal cost, and coal storage/transfer cost).

- The incremental system cost over no sulfur dioxide control

- The quantity of coal used from each mine

- The number of stack gas scrubbing systems used.

- The number of coal cleaning plants used

Following the tables is Figure 1 which is a plot of the incremental system cost in ¢/MM Btu vs. the sulfur dioxide emission level in lb/MM Btu.

Table 1

CASE 1

IOWA STUDY

8 Possible Scrubbing Locations
8 Possible Cleaning Locations

Unlimited Western Coal
Unlimited Illinois Coal
Spec : lb SO_2/MM Btu

788,400 MM Btu/D

System Cost : $/D	20	5	3.1*	1.2
TPIT **	219,517	205,165	185,502	171,510
TFRT	90,935	141,749	188,100	232,085
TASH	4,774	4,198	3,301	2,129
TSC1	-	-	-	-
TSC2	-	-	-	-
TWSH	-	-	-	-
TREF	-	-	-	-
TSTO	3,249	7,071	7,672	8,120
Cost Total	318,475	358,183	384,575	413,844
Δ Cost Over Spec 20 : $/D	-	39,708	66,100	95,369
Δ Cost Over Spec 20 : ¢/MM Btu	-	5.04	8.38	12.10
Coal Source : T/D				
MA	8,650.4	508.4	292.6	76.8
MB	-	2,406.4	1,385.0	363.6
MC	9,499.4	534.4	307.6	80.8
MD	11,383.4	19,741.5	9,978.6	1,622.3
ME	-	-	-	-
MF	7,098.0	7,683.5	13,605.7	10,193.0
MG	-	3,813.7	9,818.6	22,914.6
MH	-	-	-	-
Total	36,631.2	34,687.9	35,388.1	35,251.1
Scrubbing Systems	None	None	None	None
Cleaning Plants : T/D	None	None	None	None

*DK, DN Below Specification
** Refer to pages 240-241

Table 2
CASE 2
IOWA STUDY

8 Possible Scrubbing Locations

8 Possible Cleaning Locations

Limit = 16,000 T/D Western Coal

Unlimited Illinois Coal

788,400 MM Btu/D

(8,000 T/D Hanna, 8,000 T/D Craig)

	Spec : lb SO_2/MM Btu			
	20	5	3.1	1.2
System Cost : $/D				
TPIT	219,517	205,165	207,110	199,517
TFRT	90,935	141,749	160,788	159,133
TASH	4,774	4,198	3,356	3,762
TSCI	-	-	-	116,356
TSC2	-	-	-	39,327
TWSH	-	-	14,230	-
TREF	-	-	464	-
TSTO	3,249	7,071	8,660	7,017
Cost Total	318,475	358,183	394,608	525,112
Δ Cost Over Spec 20	-	39,708	76,133	206,637
Δ Cost Over Spec 20 : ¢/MM Btu	-	5.04	9.66	26.21
Coal Source : T/D				
MA	8650.4	508.4	-	-
MB	-	2406.4	7489.5	4171.0
MC	9,499.4	534.4	-	-
MD	11,383.4	19,741.5	12,940.4	14,902.7
ME	-	-	-	-
MF	7,098.0	7683.5	8000.0	8000.0
MG	-	3813.7	8000.0	8000.0
MH	-	-	-	-
Total	36,631.2	34,687.9	36,429.9	35,073.7
Scrubbing Systems	None	None	None	All 8 plants
Cleaning Plants : T/D	None	None	CClMB = 7489	None

Table 3
CASE 3
IOWA STUDY

788,400 MM Btu/D

8 Possible Scrubbing Locations

8 Possible Cleaning Locations

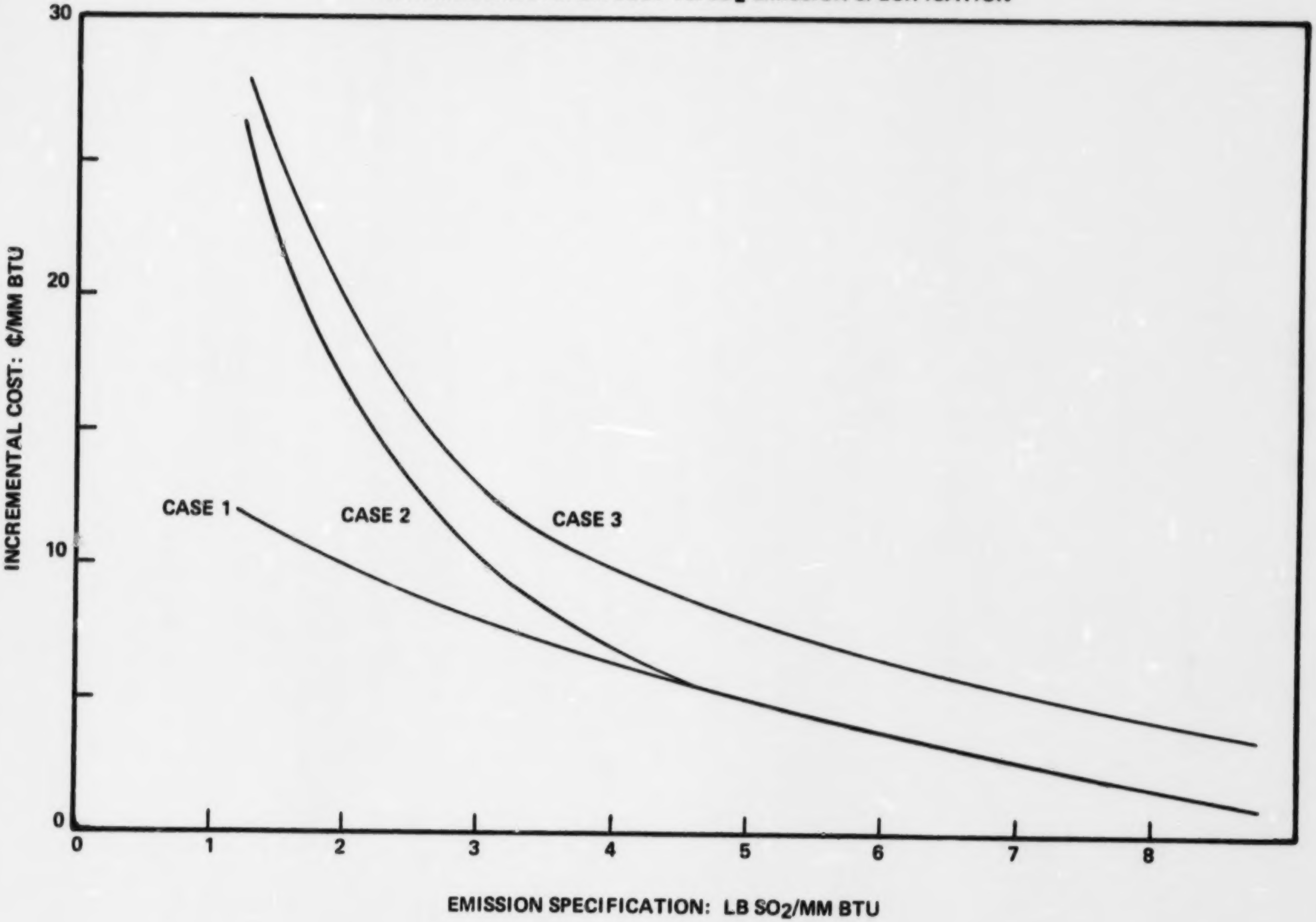
Limit= 16,000 T/D Western Coal (8,000 T/D Hanna, 8,000 T/D Craig)

Limit= 7,000 T/D Illinois Coal (7,000 T/D Marion)

	Spec :lb SO_2/MM Btu			
System Cost : $/D	20	5	3.1	1.2
TPIT	220,504	211,067	217,964	211,340
TFRT	99,144	146,210	156,680	148,898
TASH	4,784	3,471	3,019	3,489
TSC1	-	-	-	113,448
TSC2	-	-	-	45,565
TWSH	-	13,680	27,357	13,680
TREF	-	446	893	446
TSTO	2,163	6,808	9,064	6,968
Cost Total	326,595	381,682	414,977	543,834
Δ Cost Over Spec 20 : $/D	8,120	63,207	96,502	225,359
Δ Cost Over Spec 20 : ¢/MM Btu	1.03	8.02	12.24	28.58
Coal Source : T/D				
MA	11,258.4	5404.1	338.1	6885.0
MB	-	7200.0	14,398.4	7649.4
MC	11,142.2	1886.6	857.8	-
MD	7000.0	7000.0	7000.0	7000.0
ME	-	-	-	-
MF	8000.0	8000.0	8000.0	8000.0
MG	-	8000.0	8000.0	8000.0
MH	-	-	-	-
Total	37,400.6	37,490.7	38,594.3	37,534.4
Scrubbing Systems	None	None	None	All 8 plants
Cleaning Plants : T/D	None	CC1MB = 7200	CC1MB = 14,398	CC1MB = 7200

Figure 1

INCREMENTAL SYSTEM COST VS. SO_2 EMISSION SPECIFICATION



IV PROCESS DESCRIPTIONS

A. Flue Gas Scrubbing Processes

1. Wet Limestone System (Refer to Appendix B)

a. General

This task specified that two types of stack gas scrubbing processes for SO_2 removal be evaluated:

- a throw away system
- a regenerable system

The throw away process selected for SO_2 removal is the Wet Limestone process. The process design for the Wet Limestone system is based on the design proposed by the Tennessee Valley Authority for their Widow's Creek Unit 8 SO_2 removal process. This design was used because it incorporates up-to-date technology regarding wet limestone scrubbing. However some minor departures from the TVA design were taken in both the limestone handling system and the scrubbing system.

b. Limestone Handling, Grinding and the Effluent System

This system is designed for receiving limestone by both rail and truck from the limestone quarries. Limestone is unloaded into a 100 ton hopper, 101-F, located in a concrete pit below grade. The hopper is sized to accomodate unloading of railroad cars as well as trucks. The limestone is transferred from the hopper via a feeder, 101-V, to the tunnel belt conveyor, 102-V, which transfers the limestone to either the stacker, 103-V, feeding the dead storage pile or to the plant conveyor, 104-V, which feeds the live storage silos via the tripper belt, 105-V.

The limestone system for each plant is designed for running the power plant at peak capacity using coal containing the maximum sulfur content (highest monthly average for 1972). Limestone flow rate is based on 150% of the stoichiometric quantity required. Design capacity for the feeder, conveyors, stacker and tripper is five times the maximum limestone consumption rate to allow for receiving limestone in a 40 hour week while the plant operates continually. A limestone dead storage pile is sized for 30 days usage (in the event of an interruption in the supply of limestone) and the live storage silos, 102-F, are sized to hold 3 days supply (to allow the plant to operate over a 3 day weekend without receiving limestone). The live storage silos and ball mills are located in an enclosed building, 101-K, to preclude weather and fugitive dust problems.

Limestone is fed from the live storage silos to the wet ball mills, 101-L, where it is ground in closed circuit from the purchased size (3/4" x 0") to the final size (90% minus 200 mesh). The slurry from the ball mills (about 65% solids) is fed to the cyclone classifiers. Underflow from the classifiers containing oversized particles is recycled to the ball mills for regrinding.

Overflow from the cyclone classifiers flows to a mill slurry sump where sufficient water is added to reduce the solids concentration to 40%. Mill sump pumps are used to transfer the 40% limestone slurry to the limestone slurry surge tank, 103-F.

Three 33% capacity ball mills are used in each plant (based on the maximum limestone flow) allowing two mills to handle the normal limestone requirement. The limestone slurry surge tank is a carbon steel rubber-lined vessel with an agitator. It has a capacity corresponding to 4 hours storage (at maximum limestone flow), allowing the scrubbing trains to continue operating while maintenance is being done in the grinding area.

Limestone is fed to the scrubbing trains by rubber-lined centrifugal limestone slurry feed pumps, 101-J. One pump is used for each individual scrubbing train with a spare provided for each three operating pumps.

Effluent slurry containing about 15% solids flows from the venturi scrubber circulating tanks to the effluent slurry surge tank, 104-F, which is a rubber-lined carbon steel vessel with an agitator. It is sized for 5 minutes storage capacity. Rubber-lined centrifugal pumps, 104-J, send the slurry to a thickener, 102-L, which concentrates the solids to about 40%. Recycle water pumps, 103-J, return overflow water from the thickener to the scrubbing trains and the ball mills. Net make-up process water requirements comprise that which is evaporated into the gas while cooling it in the venturi scrubber and that which is lost in the sludge. This water is supplied by the raw water pumps, 102-J.

Sludge is sent from the thickener to a relatively small lined holding pond. The ponds are sized to hold about 2 weeks production of sludge. The solids portion of the sludge consists mainly of hydrates of calcium sulfite and calcium sulfate, unreacted limestone, and fly ash. Net sludge produced will have to be removed from the plant site via truck, rail, or barge.

Alternatively the thickener can be eliminated and a large settling pond used. However, lack of land precludes using this disposal method in most cases. For example, a 500 MW plant burning 5% sulfur coal would require a 241 acre by 50 feet deep pond to hold 20-years production of sludge.

Wash water is pumped from a settling pond (fly ash pond) to the entrainment separators by the wash water pumps, 106-J, at the rate of 1 gpm/ft^2 of CSA. Entrainment separator pumps, 105-J, return this water to the pond.

c. Scrubbing System

Flue gas leaves the electrostatic precipitators of the power plant boilers at essentially atmospheric pressure and at a temperature of about 300°F (ranges from 250 - 350°F). It has a fly ash loading of about 2-5 grains per actual cubic foot (gr/acf) entering the precipitators. The fly ash loading leaving the precipitators will be about 0.4-1.0 gr/acf (wet) assuming an efficiency of 80%. The SO_2 content of the flue gas will range from about 1650 to 3300 ppm (wet) with coal having an initial sulfur content of 2.5-5.0%.

Eight standard sized scrubbing trains were designed for use in this study. The largest train will treat about 545,000 acfm (hot gas) corresponding to about 167-182 mw. This is currently the largest unit being built by UOP. The smallest train will treat about 91,000 acfm which corresponds to about 28-30 mw. Each scrubbing train consists of a fan, venturi scrubber, venturi scrubber circulating tank and pumps, absorber, absorber circulating tank and pumps, an entrainment separator, and a reheater.

Flue gas from the existing electrostatic precipitators enters the fan, 203-J, in a scrubbing train. The fans are double inlet centrifugal units equipped with variable speed fluid drives. Each fan is designed for a pressure differential of 25" H_2O and a flow rate 10% above normal. The fans supply the motive power for the scrubbing system.

A venturi scrubber, 201-E, is used to cool, saturate, and remove residual fly ash and some SO_2 from the flue gas. The unit is designed for a pressure drop of 10" H_2O and a fly ash removal efficiency of about 99%. SO_2 removal in the venturi scrubber is expected to be about 20-30%. The venturi scrubber is constructed of 316 L stainless steel with an abrasion resistant lining and has a rectangular throat with a motor operated variable throat mechanism. Velocity in the throat is in the range of 200 fps. Constant speed rubber-lined centrifugal pumps, 201-J, are used to pump slurry (15% solids) from the venturi scrubber circulating tank, 201-F, to the venturi scrubber. Two pumps are provided per train - one operating and one spare and are designed to supply liquid to the venturi scrubbers at a rate of 16.1 gpm/mscfm of inlet gas (11 gpm/macfm hot gas). The venturi scrubber circulation tanks are rubber-lined carbon steel vessels provided with agitators, 201-L. They are designed for a retention time of 5 minutes (85% full) based on the venturi circulation rate. This design is similar to that used by Catalytic, Inc. (15, pp. 23-24).

Saturated gas from the venturi scrubbers (at 125°F) flows to the absorbers, 202-E. These units are UOP* Turbulent Contact Absorbers (TCA's). The absorbers are rubber-lined carbon steel vessels with 316 SS internals containing 3 beds of hollow 1-1/2" diameter thermoplastic spheres. Each bed has a static ball depth of 12" and the beds are spaced 4 feet apart. The absorbers are designed for a superficial gas velocity of 12.5 fps. They are rectangular in cross section with the largest unit being 15' x 40' and the smallest being 15' x 6.67'. Overall height of the absorbers from the bottom of the hopper is 45'. Expected SO_2 removal efficiency in the absorber is about 87% of the remaining SO_2 in the gas from the venturi giving an overall SO_2 removal efficiency of 90%. Pressure drop through the absorber is expected to be 7" H_2O.

Rubber-lined centrifugal pumps, 202-J, equipped with variable speed fluid drives are provided to pump slurry (containing 10% solids) from the absorber circulating tank, 202-F, to the absorber. Three pumps are provided per scrubbing train - two operating and one spare. The pumps are designed to supply slurry to the absorbers at a rate of 64.5 gpm/mscfm of inlet gas to the venturi. This corresponds to about 44.2 gpm/macfm of hot gas or about 40 gpm/ft^2 of CSA. Design of the unit is based on information from TVA and UOP.

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*UOP: Universal Oil Products Company (Air Correction Division)

Gas from the entrainment separator is heated from 125°F to 175°F in the reheater, 201-C, to desaturate and provide buoyancy for the gas. This unit is an indirect tubular exchanger utilizing saturated steam at 500 psig. Estimated pressure drop in the unit is 4" H_2O. The first 30% of the rows of tubes are constructed of Alloy 20 for corrosion resistance to the gas which enters at its dew point. The remaining 70% of the rows are constructed of carbon steel. A reheat ΔT of 50°F was chosen in this study because it is believed to be about the minimum acceptable value. Note that each 50°F increase of the flue gas temperature requires about 1.3% of the gross heat input into the plant.

Steam operated soot blowers are provided at locations where solids deposition is expected to occur. Soot blowers are placed in the inlet duct to the venturi, 203-L, in the elbow between the absorber and the entrainment separator, 204-L, and at the reheater, 205-L.

Gas leaving the reheater flows to the stack. Positive shut-off guillotine gates are provided at three locations - the inlet to the fan, the exit from the reheater, and a by-pass connecting the inlet and outlet ducts. These gates will make maintenance possible on one scrubbing train while the remainder of the trains continue operating.

Fresh limestone slurry, water recycle, and make-up water are added to the absorber circulating tank. Limestone is fed at 150% of the stoichiometric rate and water is added in sufficient quantity to maintain the solids concentration at about 10%. Overflow from the absorber circulating tank goes to the venturi scrubber circulating tank. The solids concentration in this tank will depend on the inlet flue gas fly ash loading but will normally run about 15%. Overflow from each venturi scrubber circulating tank goes to the effluent slurry surge tank as described previously.

Clean flue gas flowing to the stack will have a fly ash loading of about 0.01-0.02 gr/acf (wet) and an SO_2 content of about 160-320 ppm based on 90% removal in the scrubbing train.

2. Wellman-Lord Process

a. Scrubbing Section (Area 100)

The Wellman-Lord scrubbing system is designed to reduce the SO_2 content in power plant flue gases to an acceptable level for discharge to the atmosphere.

Flue gas from the boiler enters a booster fan, 101-J, which sends the gas through the system. The gas enters the absorber, 101-E where it is first pre-scrubbed with recirculating water to remove residual flyash. The water is circulated by the prescrubber circulating pumps, 103-J. The solids content in this stream is controlled by purging a small slipstream to the existing flyash disposal pond. Fresh make-up water is added in the prescrubber section. Cool, saturated gas at about 130°F is then contacted countercurrently with a sodium sulfite solution in the top section of the absorber for removal of SO_2. The Na_2SO_3 solution chemically absorbs SO_2 by the reaction:

$$SO_2 + Na_2SO_3 + H_2O \rightarrow 2\ NaHSO_3.$$

The sodium sulfite solution is circulated through the absorber via the absorber circulating pumps, 104-J.

Gas leaves the absorber after passing through a mist eliminator and flows to a reheater, 101-C. The temperature of the gas stream is raised to about 175°F to desaturate the gas and provide buoyancy for it. Clean flue gas containing only 5% of the initial SO_2 then flows to the stack.

Another reaction which may occur to some extent in the absorber when SO_3 is present in the gas is the following:

$$2Na_2 SO_3 + SO_3 \rightarrow Na_2 SO_4 + Na_2 S_2O_5.$$

Also some oxidation of the sodium sulfite solution may occur.

$$Na_2 SO_3 + 1/2\ O_2 \rightarrow Na_2 SO_4$$

The bisulfite rich solution ($NaHSO_3$) is withdrawn from the bottom of the absorber and is sent to the abosrber surge tank, 101-F.

b. Regeneration Section (Area 200)

Bisulfite rich liquid is pumped from 101-F through the flyash filters, 201-L, via the filter feed pumps, 201-J. From the filters, most of the liquid flows to the evaporator feed tank, 201-F. However, a small quantity is sent to the Purge/Make-up Section for sodium sulfate extraction.

The evaporator feed pumps, 203-J, send the solution to the evaporator, 202-F. Liquid is circulated through the evaporator heater, 201-C, by the evaporator circulating pumps, 205-J. The solution is heated in an indirect heat exchanger using low pressure steam. As the solution boils, SO_2 and H_2O vapor are released and sodium sulfite crystals precipitate from the solution. The reaction occurring in the evaporator is:

$$2NaHSO_3 \rightarrow Na_2SO_3 \downarrow + SO_2 \uparrow + H_2O \uparrow.$$

A heavy slurry of undissolved solids is maintained in the evaporator circuit by withdrawing part of the slurry and sending it to the dump/dissolving tank, 203-F.

Overhead gas from the evaporator flows to the primary condenser, 202-C, where water vapor in the gas is partially condensed. Gas leaving the primary condenser joins overhead gas from the condensate stripper and feeds the secondary condenser, 203-C, where most of the remaining water vapor is condensed. Cooling water is circulated through both the primary and secondary condensers. Condensate from both the primary and secondary condensers flows to the condensate stripper, 201-E. In this packed column, the condensate is stream stripped to remove any dissolved SO_2. The condensate from the stripper is used for redissolving the sodium sulfite crystals in the dump/dissolving tank. It is pumped through the condensate cooler, 205-C, via the condensate stripper pumps, 209-J, to 203-F.

SO_2 vapor from the secondary condenser flows through a knock-out drum and then to the SO_2 superheater, 204-C, where it is heated and then compressed by the SO_2 compressor, 210-J, and sent to the sulfur plant (Area 400).

Regenerated sodium sulfite (Na_2SO_3) solution from the dump/dissolving tank is pumped to the absorber feed tank, 204-F, via the transfer pumps, 207-J, and is then returned to the absorber (Area 100) via the absorber feed pumps, 208-J.

Soda ash (Na_2CO_3) make-up solution is added to the dump/dissolving tank where it reacts with sodium bisulfite to form additional sodium sulfite solution:

$$Na_2CO_3 + 2NaHSO_3 \rightarrow 2Na_2SO_3 + H_2O + CO_2 \uparrow .$$

c. Purge/Make-up Section (Area 300)

The purge/make-up section is designed to remove inert compounds such as sodium sulfate and sodium thiosulfate from the liquids and return sodium sulfite/bisulfite back to the SO_2 revovery unit. A side-stream is taken from the evaporator feed for sodium sulfate purge and another side-stream is taken from the dump/dissolving tank for sodium thiosulfate purge. The purge compounds are removed as dry solids after processing and sodium sulfite/bisulfite solution is returned to the evaporator.

3. Allied Chemical Process for SO_2 Reduction

In the Allied Chemical process, SO_2 produced in the Wellman-Lord process is reduced to elemental sulfur. Natural gas is used as the reducing agent. The natural gas is mixed with SO_2 from 210-J in the proper proportion for feeding the reactor-regenerator system and passed through the feed preheater, 403-C, to raise the temperature above the dew point of the sulfur that is formed in the primary reactor.

The principal function of the catalytic reduction system is to achieve maximum utilization of the reductant while producing both sulfur and H_2S such that the proper ratio of H_2S/SO_2 of 2:1 is realized for the subsequent Claus reaction. The preheated gas mixture enters the catalytic reduction system through a four-way flow reversing valve and is further heated as it flows upward through a packed bed heat regenerator, 401-DB. The gas stream then flows downward through the reduction reactor, 402-D. The temperature of the gas entering the reduction reactor is controlled by bypassing a quantity of cold gas around the upflow regenerator.

Upon leaving the reactor, the main gas flow passes downward through a second heat regenerator, 401-DA, giving up its heat to the packing in that vessel before leaving the catalytic reduction system through the flow reversing valve. A thermal balance is maintained in the system by passing a minor flow of the hot gases around the downflow regenerator and the flow reversing valve and remixing with the main stream. The direction of flow through the two heat regenerators is periodically reversed to interchange their functions of heating the feed gas and cooling the product gas.

The effluent gas from the reactor-regenerator system is further cooled in the mixed gas cooler, 404-C. Some sulfur is condensed in this unit and it flows to the sulfur pit, 401-F. Low pressure steam is generated on the shell side of this unit. A portion of the gas from the mixed gas cooler then is used to heat the feed gas in the feed preheater. Gas leaving the feed preheater enters the 1st sulfur condenser, 405-C. Low pressure steam is also generated on the shell side of this unit. Some sulfur is condensed and it is sent to the sulfur pit. Exit gas is then blended with hotter gas from the mixed gas cooler to feed the 1st Claus reactor, 403-D. Here the following exothermic reaction takes place:

$$2H_2S + SO_2 \rightarrow 3S + 2H_2O.$$

The gas is cooled in the 2nd sulfur condenser, 406-C, and the liquid sulfur formed flows to the sulfur pit. Further conversion to sulfur takes place in the 2nd Claus reactor 404-D. Sulfur is condensed in the 3rd sulfur condenser, 407-C, and flows to the sulfur pit. Low pressure steam is also generated on the shell side of the 2nd and 3rd sulfur condensers.

The gas stream then enters the tail gas mist eliminator, 401-G, for removal of entrained liquid droplets. Residual H_2S in the gas is oxidized to SO_2 in the tail gas incinerator, 401-B. Air is supplied to this unit by the dilution air blower, 403-J, and the combustion air blower, 404-J. The incinerator outlet gas containing SO_2 is recycled to the absorber in the scrubbing area to minimize SO_2 emission to the atmosphere.

Product sulfur is pumped from the sulfur pit to the sulfur storage tank, 309-F, via the sulfur pit pumps, 402-J.

B. Coal Cleaning Process (See Appendix D)

The process description which follows is based on a coal preparation plant with a capacity of 600 t/h of raw coal feed, operating two shifts/day for 220-260 days/yr. The total coal processed at such a plant would be 2.112 MMTons/yr. The site for the plant will require about 25 acres; an additional 75 acres should be acquired adjacent to the plant for refuse disposal. The utilities and manpower requirements for such a plant are itemized below:

Electric Power	
Preparation plant	2,900 HP
Materials handling and storage	500
Unloading and loading	350
Total	3,750
Manpower Requirements	
Preparation plant	25 men
Refuse handling	3 men
Intermediate storage & handling	8 men
Make-up water requirements	200 GPM

Coal is received at the preparation plant in the raw coal receiving bin, 101-F. It is transferred from there to the 1500 raw coal silo, 102-F, via a conveyor. The plant feed conveyor transports the raw coal to the preparation plant where it is first screened in the raw coal screen, 101-G, and the pre-wet screen, 102-G. This operation serves to separate the coarse coal particles (5" x 1/4") which make up about 70% of the coal feed, from the fine coal particles (1/4" x 0).

The slurry containing the fine coal particles passes first to a stationary screen (sieve bend screen, 103-G), and then to a desliming screen, 104-G. Slurry passing through this screen flows first to classifying cyclones , 116-G. The underflow from these cyclones (28M x 200M) flows to froth cells, 117-G. The overflow from the classifying cyclones (200 M x O) flows to the thickener, 102-L. Coal (1/4" x 28M) from the desliming screen, flows to the pulp sump, 103-F, where it is mixed with concentrated magnetite. This stream is then directed to the heavy media cyclone, 105-G, where gravity separation takes place. The heavy media slurry containing pyrites flows to the refuse drain and rinse screen, 106-G. Refuse is screened off here and sent to the refuse bin, 106-F, and the heavy media slurry flows through the screen to the heavy media sump, 104-F. It is picked up from the sump by the heavy media pumps, 101-J, and transferred back to the pulp sump, 103-F.

The overflow from the heavy media cyclone containing small coal particles (1/4" x 28M) flows over a second sieve bend screen, 107-G, and then to the clean coal drain and rinse screen, 108-G. Dilute magnetite flows through this screen and combined with the rinse underflow from the refuse screen, 106-G, flows to the magnetic separator, 109-G, which concentrates the magnetite and returns it to the heavy media sump. Clarified water separated here is returned to the screen sprays. Fine coal (1/4" x 28M) from 108-G then is transferred to the centrifugal dryer, 110-G. This unit separates the fine coal (1/4" x 28M), which is transferred to the clean coal silo, from a slurry. The slurry is sent to the froth cells, 117-G.

Coarse coal (5" x 1/4") which was screened off in the front end of the process is transferred to the heavy media washer, 111-G, where a gravimetric separation is made in a magnetite bath. Refuse is separated at this point and transferred to the refuse drain and rinse screen, 112-G. The rejected material (5" x 1/4") is screened off at this point and transferred to the refuse bin, 106-F, along with the remainder of the refuse. Concentrated magnetite flowing through this screen flows back to the heavy media sump, 105-F, while dilute magnetite flows to the magnetic separator, 115-G.

Coal from the heavy media washer flows to the clean coal drain and rinse screen, 113-G. Coarse coal (5" x 1-1/2") overrides this screen and is sent to the crusher, 101-L. Coal from the crusher (1-1/2" x 0) is then transferred to the clean coal silo, 107-F. Coal overriding the second deck (1-1/2" x 1/4") is then transferred to a centrifugal dryer, 114-G. Slurry is separated from the coal at this point and transferred to the froth cells, 117-G. The clean coal from the centrifugal dryer (1-1/2" x 1/4") then joins coal leaving the crusher to be transferred to clean coal storage.

Concentrated magnetite from the clean coal drain and rinse screen flows to the heavy media sump, 105-F. From here it is picked up by 102-J and transferred back to the heavy media washer. Dilute magnetite from the clean coal drain and rinse screen flows through the screens to the magnetic separator, 115-G. Concentrated magnetite from this unit flows to the heavy media sump and clarified water is returned to the screen sprays.

From the froth cells, 117-G, small coal particles (28M x 0) are sent to the clean coal filter, 118-G. Filtered coal is then transferred to clean coal storage. The filter overflow is pumped to the screen sprays. The static thickener, 102-L, receives the refuse slurry from the froth cells. A further feed to the thickener is a slurry stream which comes as the overflow from the classifying cyclones, 116-G. Refuse from the thickener is transferred to the refuse filter, 119-G. Filter cake from this unit ([illegible]8M x 0) then joins the remainder of the plant refuse. Water from this filter is returned to the screen sprays. Clarified water from the thickener is sent to 108-F from where it is returned to screen sprays.

Make-up water for the process is sent to the make-up water tank, 108-F. Water from the thickener also flows to 108-F. Water is pumped from this vessel to the screens to be used as screen spray.

A supplemental system which can be used in the coal preparation plant includes a thermal dryer, 101-B. This unit receives as feed, coal (1/4" x 28M) from the centrifugal dryer, 110-G and from the clean coal filter (28M x 0). It reduces the water content of the fine coal (1/4" x 0) to the desired surface moisture level. Dried coal from the thermal dryer is then transferred to the clean coal silo.

V. DESCRIPTIONS OF POWER PLANTS IN IOWA

A. Des Moines Plant (See Fig. 11, 23)

The Des Moines Plant is a coal, oil and gas fired steam electric power plant owned by Iowa Power & Light Company. It has a generating capacity of 325 mw, the second largest in the state. It is located on the north bank of the Des Moines River in Des Moines, Iowa.

The plant is situated just north of a bend in the Des Moines River on a site of approximately 60 acres. The plant site is bound on the south, the southwest and the southeast sides by the Des Moines River. An oil storage tank farm lies north of the plant past the coal pile. The boilers are enclosed in a building which runs in a north-south direction. West of the power house is a large cooling tower running in a northwest to southeast direction. The cooling tower is situated above its basin. A 46 kv substation is located due east of Boilers 7 and 8 and a parking lot is located due east of Boiler 11. Highway 46 runs in a north-south direction dividing the plant property. It crosses the river just east of the 46 kv substation. Just east of Highway 46 is a large 69 kv electrical switchyard and east of it is an even larger 161 kv electrical substation. North of these electrical facilities is a large ash disposal pond. The pond is approximately 900' wide and 1000' long. Railroad tracks enter the boiler area from the northwest and from the northeast.

Coal is received at the Des Moines Power Plant by rail and by truck from a number of different sources. Some western coal is burned at this plant. Total coal used in 1972 was 524,000 tons. The average properties of this coal on an as received basis are as follows:

HHV : 9400 Btu/lb
%S : 4.1
%Ash : 15.2
%Moisture : 16.9

Coal is stored in a large pile located north to northwest of the power plant.

The Des Moines plant has 6 boilers and 7 generators which range in capacity from about 30 to 110 mw. Boilers 6, 7, 8 and 9 supply steam to five turbines through a common steam header. Boilers 10 and 11 each have their own turbine and generator. The average load factor for the Des Moines power plant in 1972 was 58.5%. Boiler 6 uses gas exclusively. It is a front firing boiler. The standby fuel for this unit is No. 2 fuel oil. Boilers 7, 9 and 9 are pulverized coal, tangential-fired units. Boilers 10 and 11 are pulverized coal, front-fired units. Units 7 and 8 are tied together to a common stack 250' high. Units 9, 10, and 11 each has its own stack. These stacks are also 250' high.

Boilers 7, 8 and 9 are served by cyclones for removal of fly ash. Estimated efficiency of these units is 65%. Boilers 10 and 11 are presently served by multiple cyclones with a design efficiency of 75%. These units are scheduled to be removed in mid 1974 for the installation of new electrostatic precipitators. The new ESP's are designed to remove 99.3% of the fly ash.

B. The Pella Plant (See Fig. 33)

The Pella Plant, located in the small town of Pella (about 40 miles southeast of Des Moines), is owned and operated by the Pella Municipal Power and Light Company. The area is sparsely populated, primarily rural, and lightly industrialized.

Rated at 44 mw, the plant has operated largely on Iowa coals from nearby mines; but some consideration is being given to cleaner "foreign" coals, particularly from the West. In 1972, the 62,000 tons burned came from mines in Marion and Mahaska counties and were trucked very short distances. There are rail facilities nearby as well. The coal burned in 1972 had the following average properties:

HHV : 8800 Btu/lb
%S : 6.6
%Ash : 17.5
%Moisture : 14.8

There are six boilers in the plant, and coal, oil or natural gas are the design fuels. However, only two of the boilers, the number 6 and 7 units, are used for base-load operation; the others are either stanby units or are being phased out. The two generators are connected by a common header. The two base-load boilers are fairly new, one commissioned in 1964 and the other 1972. The average load factor in 1972 was 20.3%. The boilers are dry bottom, spreader-stoker fired units.

A new stack serves both boilers, which feed flue gas through common breeching to a new electrostatic precipitator designed for 95% efficiency. The stack is roof-mounted and stands 250 feet above grade.

The site is triangular in shape, bounded on the north and east legs by city streets and on the hypotenuse by a rail spur. Space is severely limited on-site because of the in-town location. The total area occupied by the plant is only about 3 acres. The substation is small and located west of the main building. Space for coal storage is severely limited and is situated near the cooling towers east of the building and south as well. There is no ash pond, ash being stored in a silo for periodic haulage by truck to land fill sites.

C. Iowa State University Steam and Power Plant (See Fig. 34)

This plant is located on the campus of Iowa State University in the town of Ames, in central Iowa. Although the installed generating capacity is only 25 mw, the plant consumes considerable more energy than would be expected since it provides steam for heating campus-wide.

Two of the existing five units are coal-fired, and the other three are designed for coal and gas. A new boiler which is slated for commissioning in mid-1975 will replace the old number 4 unit and will be designed to use coal, oil or gas. In past years this plant made extensive use of Iowa coals, but due to the impending sulfur-control regulations, it was expected that 1974 would see exclusively Illinois coal in use. In 1972 some 95,000 tons of coal was received by train from Iowa, Illinois and Oklahoma mines. This coal had the following properties:

HHV : 11,300 Btu/lb
%S : 4.0
%Ash : 11.5
%Moisture : 9.7

Capacity factors are high in the ISU plant, averaging some 80-90% in 1972. All of the boilers are relatively alike in size, consuming about 10-14 t/h of coal; they were added piecemeal at about 8 year intervals as demand increased. They were placed in service from 1946 to 1974. Presently there are no electrostatic precipitator installations in place or planned, but efficient multiple cyclones

(92%) are anticipated to be installed by mid-1974. Ash is trucked out to landfill sites; there is no ash pond, and temporary ash storage is handled in a silo.

Space is severely limited at the site since it is on the campus proper. Because of the presence of nearby academic and administrative buildings there is little possibility of expansion.

Coal storage is east of the main building and occupies only a few acres. The rail siding and unloading facilities skirt the north boundary, and the southern side is confined by Wallace Road. The area is somewhat hilly. There are buildings nearby in every direction. Because of the nature of the plant, there is no large switch yard and substation. Northwest of the plant are water treating and storage facilities and the cooling towers.

An old stack at the southern edge of the building is to be removed and a new one 190 feet high will serve two of the 5 units (Units 5 and 6) while the other three (Units 1,2, and 3) will be served by a 160-foot high stack.

D. Maynard Plant (See Fig. 12, 24)

The Maynard Plant is coal, oil, and gas fired steam electric plant owned by Iowa Public Service Company. It has a generating capacity of 107 mw and it is located on the north bank of the Cedar River in Waterloo, Iowa.

The plant is located on a fairly congested site. It is bound on the south and west sides by the Cedar River, on the north side by Lafayette Street and on the east side by another street. The area of the property south of Lafayette Street is about 7 acres. The ash pond, coal yard, and fuel oil storage tanks are located across Lafayette Street northwest of the boiler area. Due north across Lafayette Street is the City Water Works and adjacent to it is an industrial area. A residential area lies east of the plant across the city street. Several railroad tracks approach the boiler plant from the north side. A 69 kv substation and a 34.5 kv substation are situated northwest of the boilers.

Coal is received by rail from Illinois. In 1972, the plant used 82,000 tons of coal having the following properties as received:

HHV : 10,900 Btu/lb
%S : 2.5
%Ash : 11.0
%Moisture : 12.0

The Maynard Plant has 5 boilers and 4 generators ranging in capacity from 12 to 58 mw. Boiler 14 is base loaded and boilers 9, 10, 11, and 12 cycle in capacity. All boilers can burn coal and gas and, in addition, Unit 12 can also burn fuel oil. Average plant load factor in 1972 was 40.0%. The boilers were placed in service from 1937 to 1958. Units 9 and 14 are pulverized coal fired and Units 10 and 11 are stoker fired. Units 9, 10, and 12 are served by a common stack 220 feet high. Unit 11 has its own stack which is 220 feet high and Unit 14 also has its own stack which is 250 feet high.

Fly ash is removed from the flue gas from Boilers 9 and 11 by Western Multiclones. Boiler 10 has a Pratt-Daniel Thermix Tubular cyclone. Boiler 12 has a mechanical precipitator. Boiler 14 is served by a Joy electrostatic precipitator with a design efficiency of 99%.

E. Muscatine Plant (See Fig. 13, 25)

The Muscatine Plant is a coal fired steam electric power plant owned by the Muscatine Municipal Electric Plant. It has a total installed generating capacity of 117 mw. The plant is located on the west bank of the Mississippi River in a rural area near Muscatine, Iowa.

The plant has 4 boilers (No. 5 through No. 8) in a row facing the river with Unit 5 on the north and Unit 8 on the south. Maple Grove Road runs north-south in the narrow space between the boiler house and the Mississippi River. A 69 kv electrical substation is situated due west of Unit 8 and another substation is located west of Units 5,6 and 7. The older portion of the power plant located on the north side of Unit 5 is to be dismantled. Railroad tracks approach from both the west and the south making a large loop through the southwest quarter of the plant. The plant area east of the railroad tracks to Maple Grove Road occupies about 13 acres. Some relatively open farm land lies west of the plant.

Coal is stored in a large pile about 400' wide and 600' long which is located south of Unit 8. The plant used 251,000 tons of coal in 1972. This coal was shipped from Illinois and had the following average properties as received:

HHV : 10,900 Btu/lb
%S : 3.0
%Ash : 10.2
%Moisture : 16.4

Coal is received at the Muscatine Station by rail and by barge. The barge dock and the unloading facilities are located out over the water southeast of the plant, some 160 feet from the river bank.

The four boilers of the plant are associated with four generators ranging in capacity from 7.5 to 84 mw. Unit 5 is the smallest and is used for standby. Unit 6 is used for peaking and Units 7 and 8 are base loaded. Unit 8 rated at 84 mw is by far the largest. Average load factor in 1972 was 57.9%. Units 5,6, and 7 are spreader stoker-fired and Unit 8 is cyclone-fired. The boilers were placed in service from 1941 to 1969 and have an expected remaining life of 7-35 years. Units 5,6, and 7 will be tied together and served by one new stack 220 feet high. Unit 8 is served by its own stack 320 feet high.

Units 5 and 6 are to be served by new mechanical dust collectors rated at 80% efficiency which are to be placed in service in May, 1975. Unit 7 is presently served by a mechanical dust collector rated at 80% efficiency. In addition, a new ESP is to be installed in May, 1975 to serve Unit 7. This will be a cold side ESP rated at 90% efficiency. Unit 8 presently has a Research-Cottrell cold side ESP rated at 95% efficiency.

F. The Fair Station (See Fig. 35)

The Fair Station is located in the small town of Montpelier in southeastern Iowa; it is a Mississippi River plant with a generating capacity of 63 mw. The area is rural with light population and industrial development. The plant is owned by the Eastern Iowa Light and Power Cooperative of Wilton Junction, Iowa.

There are two boilers, placed in service in 1960 and 1967, each designed to burn coal or natural gas. The two generators have capacities of 25 and 41 mw.* There are two stacks, each roof mounted 164 feet above grade. To date the only ash collection equipment consists of multiple cyclones designed for 85% efficiency but electrostatic precipitators are planned for early 1975.

The approximate coal consumption in 1972 was 81,000 tons. This coal was delivered to the plant by barge following a rail leg from Illinois. Rail unloading facilities are also available at the plant near the river dock. Coal used in 1972 had the following average properties:

HHV : 10,900 Btu/lb
%S : 3.3
%Ash : 9.2
%Moisture : 11.3

*It is common to find plants in which name plate and 100% load ratings are not identical.

Space for future expansion is not a serious problem at the Fair Station site. Some room exists to the west of the main building and north of the building near the substation.

The coal storage pile occupies some 6.5 acres (440'x640') due east of the main plant and north of the dock. Two ash ponds are located at the opposite (west) end of the property. The larger of the two is about 2.5 acres in area while the smaller is about 220'x280' (1.5 acres). The major rail line runs east and west along the north boundary and parallel to State Highway 22. The river bounds the south property line. The total plant site covers about 28 acres.

G. The Riverside Plant (See Fig. 14, 26)

The Riverside Plant is located on the Mississippi River in the city of Bettendorf, Iowa, and is owned by Iowa-Illinois Gas and Electric Company. Generating capacity is 222 mw. The area is heavily populated, and industrial development is very heavy.

Design fuels are coal and natural gas. There are 5 boilers and 5 generators ranging in size from 16 to 140 mw. The units were placed in service from 1937 to 1961. Boilers 5-8 are pulverized coal, front-fired units and Boiler 9 is a pulverized coal, tangential-fired unit. In 1972 the average load factor for the plant was 66.2%. All of the boilers are enclosed and are served by individual electrostatic precipitator units rated at 99% efficiency. One 346' high stack serves the newest three boilers (7,8, and 9), and the two oldest ones (5 and 6) have their own stacks (each 144' high).

The plant grounds are rather crowded with equipment and auxiliary facilities. Coal storage and handling and ash storage areas are south of the plant proper; to the north are more coal facilities and storage. West of the building are parking areas, substations, rail facilities, water tanks, gas turbine houses and other facilities. The river confines the east property line.

Coal unloading facilities appear to be exclusively rail, although the plant is on the river. In 1972 all the coal used, some 472,000 tons, was brought in by rail from Illinois. This coal had the following average properties:

HHV : 10,400 Btu/lb
%S : 2.6
%Ash : 8.7
%Moisture : 16.8

The only availabe space on the property appears to be north of the main building and close to the river.

H. Burlington Plant (See Fig. 15, 27)

The Burlington Plant is a coal fired steam electric power plant owned by Iowa-Southern Utilities Co. It has a total installed generating capacity of 212 mw. The plant is located on the west bank of the Mississippi River in Burlington, Iowa which is in the southeast corner of the state.

The plant has a single boiler with the stack being located east toward the river and the turbine-generator room being located west. The plant is situated on a fairly large track of land (about 120 acres) which is bound on the east by the Mississippi River and on the northwest by the CB & Q Railroad. An old ash disposal basin (approximately 500' x 800') is located due south of the plant. A large new ash basin is located west of the coal pile and northwest of the plant. Located due west of the turbine-generator room is the main electrical substation. Railroad tracks parallel the river and enter the plant area from the north.

Coal is stored in a large pile having dimensions of about 450 feet x 450 feet. The coal pile is located north of the plant and a conveyor runs from the crusher building some 450 feet to the silo bay of the boiler. The plant used 544,000 tons of coal in 1972. It was shipped by rail from Illinois and had the following properties:

HHV	: 10,100 Btu/lb
%S	: 2.6
%Ash	: 8.2
%Moisture	: 20.5

The single boiler and generator are rated at 212 mw. The unit was built in 1968 and has a remaining life of about 25 years. Load factor in 1972 was 59.2%. The unit is designed for pulverized coal, tangential firing. It is served by a single stack 306' tall.

Fly ash is removed from the flue gas by a UOP electrostatic precipitator located on the cold side. Tested efficiency of the unit at start-up was 98.5%.

I. Dubuque Plant (See Fig. 36)

The Dubuque Plant, owned by Interstate Power Company, is located on the Mississippi River in metropolitan Dubuque. Generating capacity is 91 mw including all units and 74 mw if the two oldest boilers are excluded. The surrounding area is heavily populated and very industrialized. The plant occupies an area of about 12-15 acres.

There are 5 boilers; design fuels are coal, oil and natural gas. The boilers range in design coal consumption from 8.7 to 25.2 t/h; load factors, from 2 (for standby units) to 53.5; generating capacity, with 4 generators, 10.0 to 37.5 mw; commissioning dates, 1926 to 1959. Two oldest boilers were not fired at all in 1973. Average plant load factor in 1972 was 54.3% (based on a generating capacity of 74 mw).

There will be 2 stacks, both 106 feet above grade. Presently there is only one electrostatic precipitator installed, but two other (newer) boilers will each have ESP's by the end of 1974. All ESP's are cold side units with design efficiencies of 99%.

Coal may be delivered either by barge or by train and is stored in a yard southeast of the plant. In 1972 all of the coal used (about 121,000 T) was supplied by barge from Illinois. This coal had the following average properties:

HHV : 11,300 Btu/lb
%S : 3.2
%Ash : 10.9
%Moisture : 10.3

Space is rather limited at this site due to its in-city location. Miscellaneous city facilities and commercial interests line the plant property on three sides, and the river confines the east border. The only available room for expansion appears to be south and northeast of the main building. The precipitators and stacks are south of the building, and a rail spur passes underneath through to the river dock unloading facilities. The substations and poleyard are located to the north. One city street (E. 8th St.) passes partway through the plant area. The area to the northeast has power cables and poles in it. There is no ash pond on-site; ash is trucked away to landfill sites.

J. The Lansing Plant (See Fig. 37)

The Lansing Plant, with 3 coal-fired boilers rated at 64 mw total generating capacity, is owned by Interstate Power Company (of Dubuque). It is a Mississippi River plant serving Lansing, in northeastern Iowa and environs. The area is lightly populated, primarily rural, and lightly industrialized.

The boilers are designed for coal consumption of 7.4 to 18.5 t/h and are rated at 15 to 37.5 mw. They were commissioned in 1948 to 1957 and operated at an average load factor of 47.4% in 1972. Two stacks each 151 feet above grade, serve them.

Electrostatic precipitators will be installed on all three units before the end of 1974. The ESP's will be cold side units with design efficiencies of 99%.

Coal may be delivered either by rail or by barge. In 1972 the 154,000 tons of coal used at Lansing was delivered by barge from Illinois mines. The average properties of this fuel on an as received basis were the following:

HHV : 11,200 Btu/lb
%S : 3.0
%Ash : 10.5
%Moisture : 11.1

Future plans call for a fourth boiler, generator and precipitator system (and presumably another stack, as well) which will probably be commissioned in 1977. More immediately, changes will be made in the coal unloading and water treatment facilities.

Space is not a critical problem at this plant site; expansion space for the new unit is located directly north of the main building. A large open area west of the substation and switch yard, which lies west of the plant proper, is presently set aside for coal storage for the new unit. Also there is a small space directly southeast of the building, as well as a larger space across the rail tracks in the same direction. Additional coal storage is located farther to the west. The river curves around the north and east sides of the site. A creek runs south and east of the plant and proposed coal yard.

K. The Kapp Plant (See Fig. 16, 28)

The M. L. Kapp Plant is owned by the Interstate Power Company of Dubuque and is located on the west bank of the Mississippi River near the small town of Clinton, Iowa. Installed generating capacity is 237 mw. The area is generally rural; industrial development in the general vicinity is moderate to heavy.

The Kapp Plant has 2 coal-fired boilers, commissioned in 1947 and 1967, respectively, and 2 generators. Unit 1 is rated at 19 mw and is a pulverized coal, front-fired unit. Unit 2 is rated at 218 mw and is a pulverized coal, tangential fired unit. Average load factor for the plant in 1972 was 59.8%. Both boilers are wet-bottom units and are enclosed in the main building; both are served by separate electrostatic precipitators and stacks. (The ESP for Unit 1 will be on steam in early 1975). The stacks are located south of the building and are 210 and 245 feet tall.

The area occupied by the plant (excluding the ash pond) is about 35 acres. High-voltage switch gear is located at the northeast wall of the building; the power substations are located to the northwest on the other side of the rail spur. An ash storage pond (approximately 50 acres) is located to the west of the substations and near U.S. Highway 67. Ash is sluiced either to this pond or to an emergency settling basin north of the plant via a 10-inch sluice pipeline. Open space exists to the immediate west of the building, where a third unit was once planned; evidently this plan was subsequently abandoned,and the space is presently used for parking, storage and construction. Other than this, the only unused space inside the property line is south of the building, but this space is limited by a railroad right-of-way, a water treatment plant and one of the stacks. There is little available space nearby outside the property line. The Mississippi River bounds the east side; a city sewage disposal plant is located north of the plant on the other side of a creek skirting the north property line. The creek curves around the west side line, leaving little space between the property line and substations. To the south and southwest are DuPont facilities and ponds.

Coal for the plant was supplied (1972) from three Illinois mines by barge. Rail unloading facilities are also present. The coal yard is east of the building. Design coal consumption (100% rating) totals 103 t/h the plant used 575,000 tons of coal in 1972 having the following average properties on an as received basis:

HHV : 11,000 Btu/lb
%S : 3.1
%Ash : 11.0
%Moisture : 11.8

L. Prairie Creek Plant (See Fig. 17, 29)

The Prairie Creek Plant is a coal, oil and gas fired steam electric power plant. It has an installed generating capacity of 245 mw. Units 1, 2, and 3 are rated at 96 mw and are owned by Central Iowa Cooperative. Unit 4 rated at 149 mw is owned by Iowa Electric Light & Power Company.

The plant is located on the west bank of the Cedar River outside of Cedar Rapids, Iowa in a fairly rural area. The plant site is a long narrow strip of land of about 50 acres in area extending westward from the Cedar River. The property is bound on the north by the Chicago and Northwestern Railroad and it is bound on the east by a road. An open pasture lies to the south of the plant. A 115 kv electrical substation is situated north of the boilers. Some water treating buildings and offices lie northwest of Unit 4. A number of railroad tracks run through the property in an east-west direction. The ash disposal basin is located at the west end of the property. A parking lot is situated on the east side of the power house.

Coal is stored in a large elongated pile (about 300' wide x 2000' feet long) located south of the boilers. The plant used 497,000 tons of coal in 1972. The coal had the following properties on an as received basis:

HHV : 10,500 Btu/lb
%S : 2.5
%Ash : 8.5
%Moisture : 16.9

Coal is received at the Prairie Creek station by rail. The principle source of the coal is Illinois.

The plant has four boilers and four generators ranging in capacity from 23.5 to 149 mw. The boilers were placed in service from 1960 to 1967. In 1972 the average load factor for the plant was 53.5%. The boilers are arranged in a row with number 1 boiler located on the east side of the power house and number 4 boiler on the west side. Units 1 and 2 are peak shaving, spreader-stoker fired boilers. Units 3 and 4 are base load, pulverized coal, front-fired boilers. Units 1 and 2 share the same stack which is roof mounted and 180' above grade. Unit 3 has its own stack which is also roof mounted and 180' above grade. Unit 4 has its own stack which is located west of the power house. It is mounted at grade and 200' high.

Units 1 and 2 have multiple cyclones for fly ash removal. The design efficiency on these units is 85%. Unit 3 is served by an electrostatic precipitator designed for 98.6% removal of particulate matter. Unit 4 is served by multiple cyclones designed for 80% particulate removal. A new electrostatic precipitator is now being installed on Unit 4. Scheduled completion date is October, 1974.

M. 6th Street Station (See Fig. 38)

The 6th Street Station is a coal, oil and gas fired steam electric plant owned by Iowa Electric Light & Power Company. It has a generating capacity of 92 mw and is located in downtown Cedar Rapids, Iowa. In addition to the other fuels mentioned, the plant also burns considerable amounts of furfural waste. A substantial portion of the steam generated at the 6th Street Station is used for heating purposes.

The plant is located in a very conjested area of approximately five acres. The boilers are enclosed in a building which is located at the south corner of the property. The plant is bound on the northwest and south sides by railroad tracks and on the north side by Cedar Lake. Water storage tanks, chemical storage facilities and water treating equipment occupy the space northeast of the power house. A 33 kv electrical substation is located north of the plant. A 115 kv electrical substation lies northeast of the 33 kv substation. Immediately south of the boiler area is a small parking lot. West of the plant, across the railroad tracks is a Quaker Oats plant. There is no coal pile at this plant simply because there is no room for one. Coal is unloaded from railroad cars to a hopper and is then conveyed directly to the coal bunkers at the power plant.

The plant burned 260,000 tons of coal in 1972. Average properties of this coal on an as received basis are as follows:

HHV : 10,300 Btu/lb
%S : 2.3
%Ash : 7.6
%Moisture : 20.0

The plant has 10 boilers and 10 generators ranging in capacity from 6 to 25 mw. The boilers were placed in service from 1937 to 1950. Average load factor for the plant in 1972 was 31.4%. All boilers are pulverized coal, front fired units and all have the capability of also firing residual oil. There are 5 stacks at the 6th Street Station, each being 198' high. Boilers 1 and 2 are served by stack 1; Boilers 3 and 4 by stack 2; Boilers 5 and 6 by stack 3; Boilers 7 and 8 by stack 4; and Boilers 9 and 10 by stack 5.

Fly ash is removed from the flue gas from Boilers 1 and 2 by cylcones with a design efficiency of 47%. Four electrostatic precipitators serve the other eight boilers. The design efficiency on the ESP's serving Boilers 3-4, 5-6, and 7-8 is 98%. The design efficiency on the ESP serving Boilers 9-10 is 99.3%.

N. Sutherland Plant (See Fig. 18, 30)

The Sutherland Plant is a coal fired steam electric power plant owned by Iowa Electric Light and Power Company. It has a total installed generating capacity of 157 mw. The plant is located in a rural area near Marshalltown, Iowa.

The plant is situated on a fairly large open site of about 80 acres. The cooling tower for Unit 3 is located about 400 feet due east of Unit 3 and the cooling tower for Units 1 and 2 is located about another 300 feet due east of the other cooling tower. An ash basin (800' x 600') is located east of the cooling tower for Units 1 and 2. Coal is transported to the boilers by conveyors which enter from the north side. Some oil storage tanks are located in a tank field about 500-650 feet northwest of the boilers. A parking lot is situated just south of the boilers. A 115 kv substation is located southwest of the boiler area. There are some open areas due east as well as southeast of the boilers.

Coal is stored in a large pile (about 300' x 1000') northeast of the boilers. The plant used 199,000 tons of coal in 1972. This coal had the following properties:

HHV : 10,100 Btu/lb
%S : 2.8
%Ash : 11.7
%Moisture : 16.0

Coal is received at the Sutherland Station by rail.

The plant has three boilers and three generators ranging in capacity from 37.5 to 81.6 mw. The boiler houses are enclosed and the boilers are arranged in a row with Unit 1 to the west and Unit 3 to the east. The boilers were placed in service from 1955 to 1961. In 1972 the average load factor was 73.5%. Boilers 1 and 2 are pulverized coal, front firing types and boiler 3 is cyclone firing type. Each boiler is served by its own stack and each stack is 190 above grade.

The original installation had multicyclones on all three units for fly ash removal. Design efficiency of the units was 80%. Each boiler will have a new ESP installed for final clean up by early 1975. The new ESP's for Units 1 and 2 will be mounted on a steel structure just north of the boilers. The new ESP for Unit 3 will be mounted on the roof of the building. All new ESP's will be downstream of the air heaters (cold gas side).

VI ESTIMATES FOR FLUE GAS SCRUBBING

A. Detailed Estimates for Wet Limestone Systems

1. Results

The capital investment required to install Wet Limestone scrubbing systems on each of the eight selected Iowa power plants are tabulated below:*

Plant	Gen Cap: MW	Capital Invest: $MM	Int. During Const: $MM	Total Capital Inv: $MM	$/KW
Des Moines	325	22.1	2.2	24.3	74.60
Maynard	107	14.7	1.5	16.2	151.10
Muscatine	117	10.3	1.0	11.3	96.90
Riverside	222	17.2	1.7	18.9	85.00
Burlington	212	13.0	1.3	14.3	67.40
Kapp	237	14.5	1.4	15.9	67.00
Prairie Creek	245	17.8	1.8	19.6	80.10
Sutherland	157	15.5	1.5	17.0	108.30
Total	1622	125.1	12.4	137.5	84.80 Avg.

These estimates assume that a thickener and small pond (2 weeks storage) are provided for sludge disposal. Sludge would have to be removed from the plant site via truck, rail or barge. If a long term sludge pond were provided the capital investment required would increase. The extent of the increase would depend on several factors:

- the number of years of sludge storage provided for
- the sulfur content of the coal feed
- the type of pond lining used and thickness of the lining.

* Costs are on a January, 1974 basis.

Detailed estimates for Wet Limestone scrubbing were also prepared for the following smaller plants: Pella, Iowa State University, Fair, Dubuque, and Lansing. The average capital investment for these five plants was $171.10/kw. No detailed estimate was prepared for the Sixth Street Station due to the unusually crowded conditions existing at the plant site. These six plants were dismissed from consideration for stack gas scrubbing due to their small size (and high unit investment cost) and due to space limitations.

2. Procedure

The design proposed by the Tennessee Valley Authority for their Widows Creek Unit 8 Wet Limestone Scrubbing system was used. Some slight modifications were made in both the limestone handling system and the scrubbing system (14).

To evaluate the capital investment required for Wet Limestone Scrubbing at 13 power plants containing many boilers of different sizes, it was decided to develop several different standard size scrubber modules. It was found that eight standard scrubber modules would be sufficient to adequately cover the range of boiler sizes involved.* The largest scrubber module (Size I) is capable of treating flue gas from a boiler generating about 167-182 mw and the smallest scrubber module (Size VIII) is capable of treating the flue gas from a boiler generating about 28-30 mw. Vendor quotations were obtained for the major equipment items in the largest (Size I) scrubbing train. Costs for the smaller size trains were pro-rated down from this cost.

* The number and size of the standard scrubber modules are chosen to best match the flue gas flow from each power plant.

Prices of the major equipment items in the limestone ling and grinding system were also obtained from vendor quotations. The equipment in this area includes conveyors, pumps, motors, ball mills and the grinding building. Subcontract cost items in this area include the limestone silos, thickener, slurry tank, effluent tank, and unloading hopper. Prices for different equipment sizes were obtained so that a cost curve could be prepared for the limestone handling and grinding system.

Using the drawings obtained from the power companies, layout sketches were made showing the number, size, location, and orientation of the scrubbing modules. Also shown on the drawings were the limestone storage, handling, and grinding facilities. In addition, major revamp work needed to install the Wet Limestone Scrubbing system at each plant was indicated on the drawings.

Process flow sheets for the limestone handling and grinding system and for the scrubbing system were prepared. Three different standard scrubber module drawings were also prepared and layout dimensions were provided for them. A tabulation of the eight standard scrubber module sizes and capacities was completed. Also a tabulation of standard piping sizes for each different scrubber module was made.

The M. W. Kellogg Estimating Department was used to prepare the detailed capital estimates for the 13 Iowa power plants. General information transmitted to the Estimating Department included the following:

- cost of standard scrubber modules
- cost curve for limestone system
- standard piping sizes
- standard scrubber module drawings

- isometric scrubber module sketch
- process flow sheets
- tabulation of standard scrubber module sizes and capacities

Specific information turned over to the Estimating Department for each plant included the following:

- power plant summary sheet showing number of scrubbing trains required, the train size, train type, additional duct work required (if any) and pond size requirement
- a plot plan for the power plant showing the location of the scrubbing trains, the location of the limestone handling and grinding system, and notes indicating extra work which must be done at the power plant (such as relocation of tanks, buildings, railroad tracks, fences, miscellaneous equipment, etc.)

With this input information, the M. W. Kellogg Estimating Department prepared capital estimates for each of the 13 power plants. The estimates include major equipment as well as site preparation, steel structures, buildings, piping, electrical, instruments, insulation and paint, subcontracts, construction costs, procurement, engineering, central staff, sales tax, insurance, start up cost, contractor overhead and profit, and construction interest.*

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* Due to the nature of the task, the overall accuracy of the estimates is expected to be about 30-35% with the probability of underrun being very small.

B. Computerized Estimates

1. Wet Limestone Scrubbing Cost Model

The M.W. Kellogg model for wet limestone scrubbing was developed in a report entitled "Evaluation of R & D Investment Alternatives for SO_x Air Pollution Control Processes." This report was performed under EPA Contract 68-02-1308, Part I, Task 7 (3, pp. 83-98). The model was programmed on the Wang 720 computer to facilitate evaluation of different process variables. For a description of the process, refer to Section IV in this report. The process flow sheet and equipment list are included in the Appendix of this report. Equations used in this model are listed in the following sections:

a. General Equations

$$(1)\quad SF = \frac{(MW)\ (Btu/KWH)\ (Wt.FR.SULF)}{(Btu/LB)} \qquad \text{M LB/HR}$$

$$(2)\quad \underset{\text{(No Control)}}{SO_2\ \text{Emission}} = \frac{(2)\ (SF)\ (10^6)}{(MW)\ (Btu/KWH)} \qquad \text{LB } SO_2/\text{MMBtu}$$

$$(3)\quad \underset{\text{(After Scr)}}{SO_2\ \text{Emission}} = (1-SO_2\ \text{Removal})\begin{pmatrix} SO_2\ \text{Emission} \\ \text{No Control} \end{pmatrix}\frac{\text{LB } SO_2}{\text{MMBtu}}$$

$$(4)\quad \underset{\text{Generated}}{\text{Annual Power}} = (MW)\ (8.76)\ (LF) \qquad \text{MMKWH/YR}$$

$$(5)\quad RB = 1 + \left(\frac{RB_{MAX}-1}{3.5-1}\right)\left(R_{BASE}-1\right)$$

$$(6)\quad GB = \left(\frac{Btu}{KWH}\right)(MW)\ (0.00034196) \qquad \text{MACFM/Boiler}$$

Note: If GB is given, the program uses it.

(7) $TB = GB/550$ No. Scr. Trains/Boiler

(Note: If TB is fraction or 1, use 1 train;
If TB is > 1, use next larger integer number)

(8) $GT = GB/TB$ MACFM/Train

(9) $GP = \sum GB$ MACFM/Plant

BOILER GEN. CAPACITY: MW	R_{BASE}
<50	3.5
50-100	3.0
101-200	2.5
201-500	2.25
>500	2.0
New	1.0

b. Capital Cost Equations

(1) $$EC = \sum_{n=1}^{NA} (TB \cdot RB)\left[1041\ (GT/550)^{0.5} + 408\ (GT/550)^{0.9}\right]$$

$$+\ 238\ RP\ (GP/3{,}300)^{0.5} + 201\ (SF/28)^{0.5}$$

(2) $ES = 1680\ (SF/28)^{0.9}$ \$M

(3) $P = 5{,}000 \left(\frac{SF \cdot LF}{28}\right)^{0.9} Is + 150 \left(\frac{SF}{28}\right)^{0.5} (1 - Is)$ \$M

(4) $L = 0.39\ (EC) + 0.18\ (ES)$ \$M

(5) $M = 0.82\ (EC) + 0.09\ (ES)$ \$M

(6) $T = 170 \left(\frac{SF}{28}\right)^{0.6} (1 - IS)$ (If required) \$M

(7) $BARC = 1.15\ (EC + ES + M) + [P + 1.43\ (L)]F + T$
(If required) \$M

(8) TPI = 1.12 (1.0 + CONTIN) BARC 	$M

(9) TCR = (1.03 + CONST INT) TPI + 0.8 TO·CO
(1+F) + 0.4 ANR 	$M

(10) $\$/\text{KW} = \frac{\text{TCR}}{\text{MW}}$ 	$/KW

(11) $\$/\text{MMBtu/H} = \frac{\text{TCR}\ (10^6)}{\text{MW}\ (\text{Btu/KWH})}$ 	$/MMBtu/HR

c. Operating Cost Equations

(1) AL = 600 CL·LF (SF/28) 	$M/YR

(2) AA = 0.43 CA (SF/28) 	$M/YR

(3) AW = 230 CW·LF [(GP/3,300) + (SF/28)] 	$M/YR

(4) AF = 1,800 CF·LF (GP/3,300) 	$M/YR

(5) AE = CE·LF [213 (GP/3,300) + 35 (SF/28)] 	$M/YR

(6) ASL = 2210 (CSL) (LF) (SF/28) (1-Is) 	$M/YR

(7) ANR = AL + AA + AW + AF + AE + ASL 	$M/YR

(8) TAC = 0.237 TPI + 2.1 TO·CO (1+F) + 1.04 ANR 	$M/YR

(9) $\text{Mills/KWH} = \frac{\text{TAC}}{\text{MM KWH/YR}}$ 	Mills/KWH

(10) $¢/\text{MMBtu} = \frac{\text{Mills/KWH}\ (10^5)}{\text{Btu/KWH}}$ 	¢/MMBtu

d. Economic Factors Used for the Wet Limestone Model

Fraction SO_2 Removal	0.90
Purchased price of limestone ($/T)	4.00
Purchased price of ammonia ($/T)	50.00
Purchased price of water ($/M GAL)	0.20
Purchased price of fuel oil ($/MMBtu)	0.80

Purchased price of electricity (Mills/KWH)	8.00
Average hourly wages per Gulf Coast ($/HR)	7.00
Total number of operators	8.00
Construction interest (Fraction)	0.10
Contingency (Fraction)	0.00
Location factor	1.52
Load factor (Fraction)	0.70
Sludge disposal cost ($/T)	1.50

e. Nomenclature - General and Fixed Capital Investment

GP	Total flue gas from plant	MACFM
GT	Maximum flow of gas into each venturi (Maximum value of GT = 550)	MACFM
GB	Total flue gas from one boiler	MACFM
NA	Number of boilers/plant	
TB	Number of scrubbing trains/boiler	
SF	Maximum flow of sulfur into the control unit	M LB/HR
LF	Load factor of the power station	
E	Major equipment cost (Material and subcontract)	$M
M	Other material costs (piping, instruments, electrical, civil etc.)	$M
L	Direct field labor costs	$M
C, S	Letters follows E, M and L C refers to chemical process type equipment S refers to solid handling equipment	
P	The total cost of the settling pond (Material and total labor)	
T	Thickener cost if required (subcontract)	$M
RB	The retrofit difficulty factor of a boiler	
RP	The retrofit difficulty factor of all scrubbing equipment which is not in parallel trains. Assume to be equal to the highest RB	
F	Location Factor	
Is	Sludge pond indicator (Is= 1 for large pond; Is= o for small pond and thickener)	

CONST INT	Construction Interest	
CONTIN	Contingency	
BARC	Bare cost of control unit	$M
TPI	Total plant investment	$M
TCR	Total capital required	$M

Nomenclature - Operating Cost

AL	Total annual cost of limestone	$M/YR
AA	Total annual cost of ammonia	$M/YR
AW	Total annual cost of process water	$M/YR
AF	Total annual cost of fuel oil	$M/YR
AE	Total annual cost of electricity	$M/YR
ASL	Total annual cost of sludge disposal	$M/YR
ANR	Summation of annual costs of chemicals, utilities, etc.	$M/YR
CL	The purchase price of limestone	$/T
CA	The purchase price of ammonia	$/T
CW	The purchase price of process water	$/M GAL
CF	The purchase price of fuel oil	$/MM Btu
CE	The purchase price of electricity	Mills/KWH
CSL	Cost of sludge disposal	$/T
TO	Total number of operators	
CO	The direct cost of operating labor	$/HR
TAC	Total annual production cost	$M/YR

2. Wellman-Lord/Allied Cost Model

The M.W. Kellogg model on stack gas scrubbing using the Wellman-Lord/Allied process was also derived from the report entitled "Evaluation of R & D Investment Alternatives for SO_x Air Pollution Control Processes" (3,pp.110-129). For a description of the process, refer to Section IV in this report. The process flow sheets and equipment lists are given in the Appendix of this report. The equations used in the model which was also programmed on the Wang 720 computer are given in the following sections:

a. General Equations

(1) $$SF = \frac{(MW)\ (Btu/KWH)\ (WT.FR.SULF)}{(Btu/LB)} \qquad \text{LB/HR}$$

(2) $$\underset{\text{(No Control)}}{SO_2\ \text{Emission}} = \frac{(2)\ (SF)\ (10^6)}{(MW)\ (Btu/KWH)} \qquad \text{LB } SO_2/\text{MMBtu}$$

(3) $$\underset{\text{(After Scr.)}}{SO_2\ \text{Emission}} = (1-SO_2\ \text{Removal}) \begin{pmatrix} SO_2\ \text{Emission} \\ \text{No Control} \end{pmatrix} \quad \frac{\text{LB } SO_2}{\text{MMBtu}}$$

(4) $$\underset{\text{Generated}}{\text{Annual Power}} = MW(8.76)\ (LF) \qquad \text{MM KWH/YR}$$

(5) $$RB = 1.0 + \left(\frac{RB_{MAX} - 1}{3.5 - 1}\right)\left(R_{BASE} - 1\right)$$

(6) $$GB = \left(\frac{Btu}{KWH}\right) (MW)\ (0.00034196) \qquad \text{MACFM/Boiler}$$

Note: If GB is given, the program uses it.

(7) $$TB = GB/550 \qquad \text{No. Scr. Trains/Boiler}$$

(Note: If TB is fraction or 1, use 1 train; if TB is > 1, use next larger integer no.)

(8) $GT = GB/TB$ MACFM/Train

(9) $GP = \sum GB$ MACFM/Plant

The following table is used for R_{BASE}:

PLANT GEN. GAP: MW	R_{BASE}
<50	3.5
50-100	3.0
101-200	2.5
201-500	2.25
>500	2.0
New	1.0

b. Capital Cost Equations

(1) $$EA = \sum_{n=1}^{NA} (TB \cdot RB) \left[726\ (GT/550)^{0.5} + 639\ (GT/550)^{0.9}\right]_n + 119\ RP\ (GP/3300)^{0.5} + N7 \left[133\ (S7/7)^{0.5} + 127\ IF\ (S7/7)^{0.6}\right]$$ \$M

(2) $$ES = N7\left[209\ (S7/7)^{0.5} + 618\ (S7/7)^{0.6} + 157\ (S7/7)^{0.9}\right]$$ \$M

(3) $$EP = N28\left[525\ (S28/28)^{0.5} + 380\ (S28/28)^{0.6} + 86\ (S28/28)^{0.7} + 306\ (S28/28)^{0.8} + 519\ (S28/28)^{0.9}\right]$$ \$M

(4) $ER = 998\ (SF/28)^{0.5} + 287\ (SF/28)^{0.6}$

$+ 683\ (SF/28)^{0.9}$ $M

(5) $M = 0.429\ EA + 0.742\ ES + 0.827\ EP + 0.772\ ER$ $M

(6) $L = 0.224\ EA + 0.310\ ES + 0.433\ EP + 0.623\ ER$ $M

(7) $BARC = 1.15\ (E+M) + 1.43\ (L)(F)$ $M

(8) $TPI = 1.12\ (1.0 + CONTIN)\ BARC$ $M

(9) $TCR = (1.03 + CONST\ INT)\ TPI + 0.8\ TO \cdot CO\ (1+F)$
$+ 0.4\ ANR$ $M

(10) $\$/KW = \frac{TCR}{MW}$ $/KW

(11) $\$/MMBtu/HR = \frac{TCR\ (10^6)}{MW\ (Btu/KWH)}$ $/MM Btu/HR

c. Operating Cost Equations

(1) $AS = 28.2\ CS \cdot LF\ (SF/28)$ $M/YR
(2) $AAO = 0.04\ CAO \cdot LF\ (SF/28)$ $M/YR
(3) $AN = 1460\ CN \cdot LF\ (SF/28)$ $M/YR
(4) $AFA = 1.24\ CFA \cdot LF \cdot IF\ (GP/3300)$ $M/YR
(5) $AE = [154\ (GP/3300) + 79\ (SF/28)]\ CE \cdot LF$ $M/YR
(6) $AH = 5430\ CH \cdot LF\ (SF/28)$ $M/YR
(7) $ACW = [856\ (GP/3300) + 19{,}900\ (SF/28)]\ CCW \cdot LF$ $M/YR
(8) $AW = 64\ (SF/28)\ CW \cdot LF$ $M/YR
(9) $AF = 1{,}800\ (GP/3300)\ CF \cdot LF$ $M/YR
(10) $ASC = 95.4\ (SF/28)\ VSC \cdot LF$ $M/YR
(11) $APS = 37.3\ (SF/28)\ VPS \cdot LF$ $M/YR
(12) $ANR = AS + AAO + AN + AFA + AE + AH + ACW$
$+ AW + AF + ASC + APS$ $M/YR

(13) $TAC = 0.237\ TPI + 2.1 \cdot TO \cdot CO\ (1+F) + 1.04\ ANR$ $M/YR

(14) $\text{Mills/KWH} = \dfrac{TAC}{MMKWH/YR}$ Mills/KWH

(15) $¢/MMBtu = \dfrac{(\text{Mills/KWH})\ (10^5)}{Btu/KWH}$ ¢/MMBtu

d. Values of Economic Factors

Fraction SO_2 Removal	0.95
RB Max.	
Purchased Price of Na_2CO_3: CS ($/T)	40.00
Purchased Price of Anti-oxidant: CAO ($/T)	40.00
Purchased Price of Natural Gas: CN ($/MSCF)	0.50
Purchased Price of Filter Aid: CFA ($/T)	50.00
Purchased Price of Electricity: CE (Mills/KWH)	8.00
Purchased Price of Steam: CH ($/MLB)	0.70
Purchased Price of Cooling Water: CCW ($/MGAL)	0.02
Purchased Price of Water: CW ($/MGAL)	0.20
Purchased Price of Fuel Oil: CF ($/MMBtu)	0.80
Value of Sulfur Credit: VSC ($/LT)	10.00
Cost of Purge Solids Disposal: VPS ($/T)	1.50
Location Factor: F	1.52
Load Factor: LF (Fraction)	0.70
IF (If fly ash present, IF = 1.00)	1.00
R_{BASE}	
Average Hourly Wages, Gulf Coast: CO ($/HR)	7.00
Total Number of Operators: TO	16.00
Construction Interest (Fraction)	0.10
Contingency (Fraction)	0.00

e. Nomenclature - General and Fixed Capital Investment

GP	Total flue gas to control plant	MACFM
GT	Total flue gas to each absorber train (maximum value of GT = 550)	MACFM
GB	Total flue gas from one boiler	MACFM
NA	Number of boilers per plant	
TB	Number of absorber trains per boiler	

SF	Total sulfur flow in flue gas to control plant	M LB/HR
S7	Total sulfur flow in flue gas to control unit per train of sulfur-related equipment in absorber and SO_2 regeneration areas (maximum value of S7 = 7).	M LB/HR
S28	Total sulfur flow in flue gas to control unit per equipment train in the purge/make-up area (maximum value of S28 = 28)	M LB/HR
N7	Number of trains of sulfur-related equipment in the absorber and SO_2 regeneration areas.	
N28	Number of equipment trains in the purge/make-up area	
E	Major equipment cost (direct material and subcontracts)	$M
M	Field Materials Costs	$M
L	Field Labor Costs	$M
A,S,P,R	Letters following E, M, L A refers to absorber area S refers to SO_2 regeneration area P refers to purge/make-up area R refers to SO_2 reduction area No letter following refers to total for all areas	
F	Location Factor	
LF	Load Factor of Power Plant	
IF	Particulate index (IF = 1 if particulates are present in flue gas. IF = 0 if particulates are absent)	
RB	Retrofit difficulty factor of each boiler	
RP	Retrofit difficulty factor of gas-related equipment in the absorber area which is not in parallel trains, i.e., the fuel oil system; assumed to be equal to the highest RB.	
CONST INT	Construction interest	

CONTIN	Contingency	
BARC	Bare cost of the control unit	$M
TPI	Total Plant Investment	$M
TCR	Total Capital Required	$M

Nomenclature - Operating Cost

AS	Annual cost of sodium carbonate	$M/YR
AAO	Annual cost of anti-oxidant	$M/YR
AN	Annual cost of natural gas	$M/YR
AFA	Annual cost of filter aid	$M/YR
AE	Annual cost of electric power	$M/YR
AH	Annual cost of steam	$M/YR
ACW	Annual cost of cooling water	$M/YR
AW	Annual cost of process water	$M/YR
AF	Annual cost of fuel oil	$M/YR
ASC	Annual sulfur credit	$M/YR
APS	Annual purge solids credit or debit	$M/YR
ANR	Summation of annual costs of chemicals, util., etc.	$M/YR
CS	Purchase price of sodium carbonate	$/T
CAO	Purchase price of anti-oxidant	$/T
CN	Purchase price of natural gas	$/MSCF
CFA	Purchase price of filter aid	$/T
CE	Purchase (or transfer) price of electricity	Mills/KWH
CH	Purchase (or transfer) price of steam	$/M LB
CCW	Cost of cooling water	$/M GAL
CW	Cost of process water	$/M GAL
CF	Purchase price of fuel oil	$/MM Btu
VSC	Unit value of sulfur (negative if credit)	$/LONG TON
VPS	Unit value of purge solids (negative if credit)	$/T
TO	Total number of operators	
CO	Unit cost of operating labor	$/HR
TAC	Total annual production cost	$M/YR

C. Comparative Economics of Wet Limestone vs. Wellman-Lord/Allied Processes for SO_2 Removal

1. General

The M.W. Kellogg estimating department prepared capital estimates for wet limestone scrubbing for 13 power plants in the state of Iowa. Out of these 8 were selected as potential candidates for a scrubbing process. The others were rejected due to either lack of space for installing the equipment or due to the small size of the power plants. The plants selected as potential sites for scrubbing facilities are the following:

Des Moines Plant
Maynard Plant
Muscatine Plant
Riverside Plant
Burlington Plant
Kapp Plant
Prairie Creek Plant
Sutherland Plant

The estimating department capital cost estimates for these plants ranged from 67.0 to 151.1 $/kw. The average for the eight was $84.80/kw. The cost model for wet limestone scrubbing using $RB_{MAX} = 1.0$, predicted an average cost of $62.30/kw. It was found that the model using $RB_{MAX} = 1.7$ and $R_{BASE} = 3.5$, predicted an average capital investment cost of $86.40/kw for the eight plants involved. This figure is almost identical to the capital cost predicted by the estimating department. Incremental capital investment required over that which would be required by a new plant is $24.10/kw on the average for the eight plants.

The scrubbing train area required for the Wellman-Lord/Allied process is identical to that required by the Wet Limestone process for a scrubber capable of processing a given quantity of gas. Also the space required for the regeneration, purge/make-up, and SO_2 reduction areas is similar to that required in the Wet Limestone system for limestone storage, handling and grinding. Therefore, the assumption was made that the degree of difficulty in retrofitting either process would be the same. That is, if one process would require additional duct work, relocation of buildings, coal piles, railroad tracks or other miscellaneous expenses, the other process would require the same.

Using the computer program for the Wellman-Lord/Allied process, the capital investment required for the eight plants (using RB_{MAX} = 1.0) ranged from 72.1 to 106.4 \$/kw with the average being 87.1 \$/kw. Using the program with RB_{MAX} = 1.7 and R_{BASE} = 3.5 the computer predicted an average cost of 109.8 \$/kw. Therefore, the incremental investment for retrofitting the plants is 22.7 \$/kw (almost identical to that for the Wet Limestone system).

2. Economic Comparison of the Wet Limestone Process vs. the Wellman-Lord/Allied Process

a. Basic Assumptions

Heat Rate = 11,000 Btu/KWH
HHV = 10,000 Btu/lb
RB_{MAX} = 1.7
R_{BASE} = 3.5
F = 1.52
LF = 0.70
CSL = 1.50/T

The heat rate of 11,000 Btu/kwh and HHV (of coal) of 10,000 Btu/lb were used as they represented the approximate average values for the eight plants selected as scrubbing candidates in the State of Iowa. As noted above, the RB_{MAX} of 1.7 and R_{BASE} of 3.5 are used to calculate the increased cost of retrofitting stack gas scrubbing systems into existing plants in Iowa. The location factor (F) of 1.52 represents the ratio of Iowa labor cost to Gulf Coast labor cost. The load factor of 0.7 was chosen as a practical average power plant load factor, although this may vary from plant to plant and from area to area. The actual load factor that a power plant will operate at in a future year is difficult to predict because of the uncertainty of the rate of population growth as well as that of industrial growth in the area. The cost of sludge disposal for the Wet Limestone process was assumed to be $1.50/T. Other economic factors such as the prices of chemicals, utilities and by-products are given in the preceding section of this report.

b. Specific Comparison of the Two Processes

The following table presents the econonmics of the two processes:

	¢/MMBtu					
	2%S		4%S		6%S	
PLANT GEN. CAP.: MW	W.L.*	W-L/A**	W.L.	W-L/A	W.L.	W-L/A
125	36.7	44.1	43.2	56.4	49.6	68.6
250	34.3	37.2	40.5	49.2	46.8	61.3
500	32.7	33.5	38.9	45.3	45.0	57.2
1000	31.0	30.6	37.0	42.4	43.0	54.1

* Wet Limestone

** Wellman-Lord/Allied

As can be seen from the above table, the Wet Limestone process is less expensive to operate than the Wellman-Lord process in all cases. The two processes are essentially equal in cost, in plants 250mw in size and larger, only when the percent sulfur in the coal is very low (between 1 to 2%).

The following general conclusions can be drawn from the table and also from the graph which is a plot of ¢/MMBtu vs. percent sulfur in the coal with plant sizes as parameters. This graph is noted as Figure 2.

(1) As expected, the operating cost in ¢/MMBtu drops as the plant size increases. For the Wet Limestone process using (4% S coal), the cost drops from 43.2 ¢/MMBtu for a 125 mw plant to 37.0 ¢/MMBtu for a 1,000 mw plant. The drop is even more drastic for the Wellman-Lord/Allied process with the cost dropping from 56.4 ¢/MMBtu for a 125 mw plant to 42.4 ¢/MMBtu for a 1000 mw plant.

(2) For a given plant size (in megawatts), the cost of scrubbing in ¢/MMBtu increases linearly as the %S in the coal increases. The scrubbing system cost for the Wellman-Lord/Allied system is more sensitive to %S in the coal than is the Wet Limestone scrubbing system. For example, a 250 mw power plant using the Wellman-Lord/Allied scrubbing system is estimated to have an operating cost of 37.2 ¢/MMBtu using 2% S coal and a cost of 61.3 ¢/MMBtu using 6% S coal. This represents an increase in operating cost of 6.02 ¢/MMBtu/%S. The Wet Limestone scrubbing system for a 250 mw power plant is estimated to have an operating cost of 34.3 ¢/MMBtu using 2% S coal and 46.8 ¢/MMBtu using 6% S coal. This represents an increase in cost of 3.12 ¢/MMBtu/% S for a given plant size.

c. Detailed Economic Comparison of the Two Processes When Installed on a 500 MW Power Plant

(1) The following table gives a detailed breakdown of the capital and operating cost for the two processes.

Table 4

	500 MW WELLMAN-LORD/ALLIED			500 MW WET LIMESTONE	
	2.545%S	5.09%S		2.545%S	5.09%S
$/KW	84.39	113.51		77.37	83.07
Mills/KWH	4.04	5.66		3.79	4.65
¢/MMBtu	36.72	51.54		34.50	42.29
Capital Costs: M$					
EA	9,011	9,531	EC	9,402	9,461
ES	1,968	3,936	ES	900	1,680
EP	1,129	1,816	P	106	150
ER	1,261	1,968	T	112	170
M	7,232	10,030		7,791	7,909
L	3,903	5,367		3,829	3,992
BARC	32,173	43,037		29,402	30,982
TPI	36,034	48,202		32,931	34,700
TCR	42,196	56,758		38,683	41,533
Operating Costs: M$/YR					
AS	394	790	AL	840	1,680
AAO	1	1	AA	11	22
AN	255	511			
AFA	25	25			
AE	713	934		777	875
AH	1,330	2,660			
ACW	146	285			
AW	4	9		34	50
AF	575	575		575	575
ASC	-334	-668			
APS	20	39	ASL	1,160	2,320
ANR	3,129	5,161		3,397	5,522
TAC	12,387	17,384		11,634	14,263
SF: M#/HR	14	28		14	28
TB(No. SCR. Trains)	4	4		4	4
N7(No.REGEN.Trains)	2	4			
N28(No.Purge/Make-up Trains)	1	1			
Breakdown of TAC					
0.237 TPI	8,540	11,424		7,805	8,224
2.1(TO)(CO)(1+F)	593	593		296	296
1.04 ANR	3,254	5,367		3,533	5,743
	12,387	17,384		11,634	14,263

Detailed examination of the table yields the following conclusions:

(a) Using low sulfur coal (2.545 %S), the Wellman-Lord/Allied process is just slightly more costly than the Wet Limestone process (36.72 vs. 34.50 ¢/MMBtu - a difference of only about 2.2 ¢/MMBtu). Most of the increased cost for the Wellman-Lord/Allied process lies in higher fixed capital charges (due to the presence of considerably more equipment in the regeneration area, purge make-up area and SO_2 reduction area, than is required in the limestone system). The variable cost of chemicals, utilities and waste disposal are somewhat higher for the Wet Limestone process but this is offset by lower labor charges.

A comparison of the processes using a fairly high sulfur coal (5.09 %S) gives an even larger advantage to the Wet Limestone process. Its operating cost is expected to be about 42.29 ¢/MMBtu vs. 51.54 ¢/MMBtu for Wellman-Lord/Allied - a difference of 9.2 ¢/MMBtu. Again, as with the low sulfur case, capital charges on the substantially higher investment for the Wellman-Lord/Allied process make up the difference in cost. As previously indicated, the variable cost of chemicals, utilities and purge disposal is somewhat higher for the Wet Limestone process, but this is offset by lower labor charges.

(b) Now we can address the problem of sludge disposal cost for the Wet Limestone process.

As previously indicated, a cost of $1.50/Ton of wet sludge (40% solids) was used for the Wet Limestone sludge disposal cost. For the 2.545% sulfur case, a sludge disposal cost of $2.44/Ton would bring the Wet Limestone process cost up to a figure equal to the Wellman-Lord/Allied cost (36.72 ¢/MMBtu). For the high sulfur coal case (5.09% S), a sludge disposal cost of $3.44/Ton for the Wet Limestone process would bring its operating cost up to that of the Wellman-Lord/Allied process (51.54 ¢/MMBtu). It is worthy of note that it does not appear to be economical or feasible to pay more than about $1.50/Ton for sludge disposal as used in the economic calculations in this study. The reason for this is the fact that the use of a large disposal pond (20 years storage) provides a more viable economic alternative for sludge disposal rather than paying extremely high sludge disposal costs.

For example, using the Wet Limestone process and 2.545% S coal, it is estimated that the use of a large disposal pond would reduce the operating cost to 33.02 ¢/MMBtu vs. 34.50 ¢/MMBtu when using a sludge disposal cost of $1.50/Ton. The incremental capital investment required for a plant with a 20 year disposal pond vs. one which has a small pond and thickener is about $7/kw.

For the 5.09 % S coal case, it is estimated that the use of a large (20 year) storage pond would reduce the operating cost of the Wet Limestone process to 39.16 ¢/MMBtu vs. 42.29 ¢/MMBtu using a sludge disposal cost of $1.50/Ton. The incremental capital investment for installing a large disposal pond rather than having a small pond and thickener is about $12/kw for the 5.09 %S case.

In some power plants, particularly those located in cities, there simply is no room for a large disposal pond. If this is the case, one posssible alternative would be to transport the sludge out of the city to an open area where a large pond could be installed.

(c) An examination of the operating cost for chemicals, utilities, sulfur credit and sludge disposal (at 5.09 %S coal) indicates that the most significant contribution to operating cost for the Wellman-Lord/Allied process is the steam cost. The most significant contribution to operating cost for the Wet Limestone process is the sludge disposal cost (at $1.50/Ton). If a 40% savings in steam could be realized for the Wellman-Lord/Allied process using double effect evaporators, the operating cost would drop by about 3.1 ¢/MMBtu to 48.4 ¢/MMBtu vs. 42.29 ¢/MMBtu for the Wet Limestone process.

The cost of electric power is about the same for both processes as is the cost of fuel used for reheat. For the Wellman-Lord/Allied process, the costs of filter aid, cooling water, process water, and the cost for disposal of purge solids are rather insignificant. The sulfur credit of $10/long ton is mildly significant. If this credit were reduced to 0, the operating cost for the Wellman-Lord/Allied process would rise by about 2¢/MMBtu.

As previously mentioned, the sludge disposal cost for the Wet Limestone process makes the most significant contribution to the variable operating cost. The next most important contribution is made by the limestone cost.

Fairly insignificant in the operating cost picture are the costs of ammonia and make-up water.

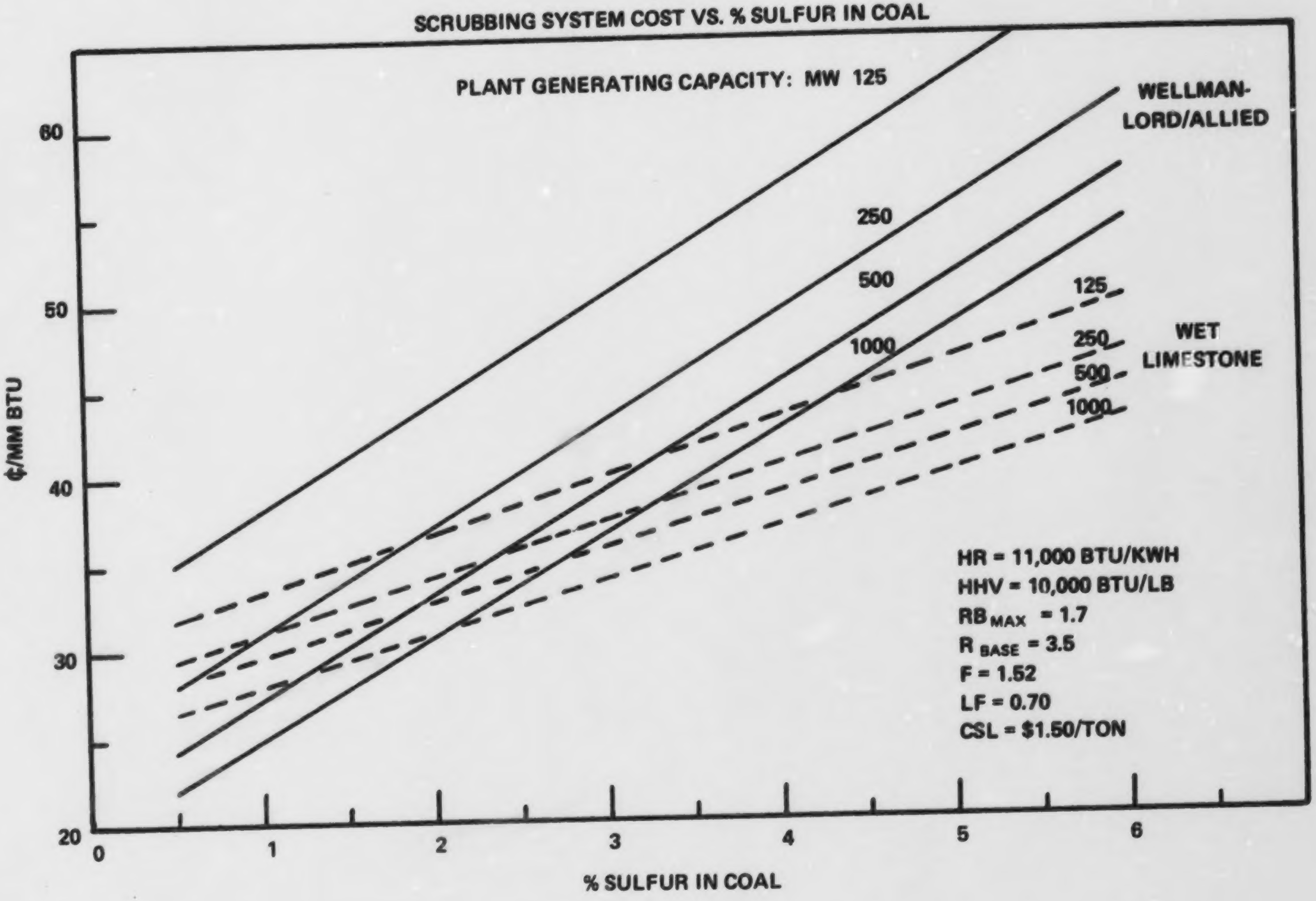
3. Conclusions Regarding Stack Gas Scrubbing as Used in the Iowa Study

   a. Since the Wet Limestone process (with sludge disposal at $1.50/Ton) appears to be more economic than the Wellman-Lord/Allied process, the costs for this process were used in the linear computer program for the Iowa study. From the graph, (See Figure 2), it can be seen that for a 250 mw power plant (note that the average size of the eight power plants in Iowa is about 203 mw) that the operating cost is about 40.5 ¢/MMBtu using 4% S coal and 43.6 ¢/ MMBtu using 5% S coal.

   b. If the Wellman-Lord/Allied process costs were used, then the cost for stack gas scrubbing would be about 49.2 ¢/MMBtu using 4% S coal and 55.2 ¢/MMBtu using 5% S coal.

Figure 2

SCRUBBING SYSTEM COST VS. % SULFUR IN COAL



VII. LINEAR PROGRAMMING MODEL

A. A Brief Discussion of Linear Programming

1. Linear Programming

Linear programming deals with the problem of allocating limited resources among competing activities in an optimal manner. The great variety of situations to which linear programming can be applied is indeed remarkable. Linear programming uses a mathematical model to describe the problem of concern. The adjective "linear" means that all the mathematical functions in this model are required to be linear functions. The word "programming" is essentially a synonym for planning. Thus, linear programming (LP in brief) involves the planning of activities in order to obtain an " optimal" result (according to the mathematical model describing the problem of concern) from all feasible alternatives.

A typical LP problem can be described mathematically as follows:
Find X_1, X_2, X_3 ..., X_n that maximizes or minimizes the linear function

$$Z = c_1X_1 + c_2X_2 + c_3X_3 + \dots + c_nX_n$$

Subject to the restrictions

$$a_{11}X_1 + a_{12}X_2 + \dots + a_nX_n < b_1$$
$$a_{21}X_1 + a_{22}X_2 + \dots + a_{2n}X_n < b_2$$
$$a_{m1}X_1 + a_{m2}X_2 + \dots + a_{mn}X_n < b_m$$

and $X_1>0, X_2>0 \ldots, X_n>0$

where a_i, b_i, c_i are given constants.

The function being maximized or minimized is called the objective function and the restrictions are called the constraints or restraints.

If a real world problem can be defined in terms of such equations then this will be a linear programming model of the problem. For further discussion on linear programming the reader should refer to any text book on operations research (19).

2. Simplex Method

The "Simplex Method" is the method for solving any linear programming problem. This is an algebraic procedure which progressively approaches the optimal solution through a well defined iterative process until optimality is finally reached. Even though the method is straightforward it requires considerable time if done manually. The difficulty in finding the solution is greatly increased with number of constraints and the number of unknowns entering the LP model. However, an LP model can be easily solved using an electronic computer.

3. Special Types of Linear Programming Problems

As pointed out in the above discussion on linear programming, LP can be applied to different practical problems. One of the common and widely used applications of LP is to transportation or transhipment problems. A typical transportation problem determines optimal shipping patterns between different sources of supply and points of demand under the constraints of demand and supply.

4. Handling of Non-Linear Relationships

Certain functions related to economic decisions are non-linear in nature and not directly applicable to linear programming treatment. Some common examples include the capital cost versus capacity of a process unit in any investment model, costs functions for shipping a product by common carrier, etc. Many of the non-linear relationships can be adequately represented using linear segments approximating the desired curve. There are techniques for handling non-convex functions in an LP environment and the ones most commonly used are:

- Separable programming
- Integer programming
- Mixed integer programming

5. Kellogg's Experience With Linear Programming

Over the years, the M. W. Kellogg Company has utilized linear programming and other related computer techniques in process, economic and cost studies for clients within the process industry. Some of these applications have included

- Refineries
- Gasoline Blending Model
- Kellogg's Olefin Plant LP System
- Fuels Refinery System

The proper selection and application of computer software for compiling and solving LP problems requires a thorough knowledge of the problem and the sensitivity of the needs of the user. The major aspects of the LP software package include

MAGEN and MPSX.

MAGEN (6) is a software system developed by Haverly Systems, Inc. to generate a matrix. Through classification of related variables and restrictions, LP problems can be generalized by type, thus making it easy for the user to supply pertinent data in a convenient tabular form and define his own terms.

The IBM (MPSX) Mathematical Programming System Extended (7) is a set of procedures containing linear programming optimization codes from which a user can select a strategy for solving an LP problem.

KELPLANS, Kellogg Planning and Analysis Systems, are the effective resultants of process engineering and computer applications toward a realistic optimum solution to complex economic problems.

B. The Definition of the Problem in Terms of an LP model

The earlier sections have already discussed the objective of this study in great detail. Stated again, we want to find the minimum overall system cost ($/day) for different transportation patterns, for various SO_2 emission specifications, under the constraints of the system. These constraints are developed by generating suitable equations containing variables that relate the different parameters of the system. The mathematical model will use the values of the constants for the equations from the input data tables given in Section III. As stated in Section III of this report there are so many variables affecting the overall cost of controlling SO_2 emissions from power plants in the State of Iowa that a mathematical model (LP model in this case) has to have a certain convenient nomenclature to cover all the possible variables to be determined in the objective function (costs) and the constraints.

1. Objective of the LP model

The purpose of the model is to minimize total system costs by determining the optimal sources and distribution routes for the coal needed by various power generation stations in the State of Iowa while complying with the effluent specifications established by the EPA. It is anticipated that some of the coal may require treatment to reduce the emission of SO_2, and, if so, the number and locations of the treatment plants will be determined. It is also expected that stack gas scrubbing may be required to meet the more stringent regulations (particularly if low sulfur coal is limited). If so, the number and locations of the scrubbing systems will be determined.

2. Basic Assumptions of the Model

The model is based upon the following assumptions:

a. The energy requirement of each power generating plant (expressed as MMBtu/day) must be satisfied.

b. Assuming total conversion of sulfur in the coal to SO_2, emissions must not exceed a certain specification in pounds of SO_2 per MMBtu of energy requirement.

c. The emission specification can be attained by selective use of low sulfur coal, by reducing the sulfur content of the coal (cleaning), and/or by treating the exhaust gases to reduce the emission of SO_2 (scrubbing).

The cleaning process removes most of the pyrites which contain proportionately more sulfur than does the coal. The ash content of the coal is reduced somewhat, and the heat content somewhat increased.

The scrubbing process removes most (90%) of the SO_2 in the exhaust gases. The wet limestone scrubbing process costs were used in the model because they appeared somewhat lower than Wellman-Lord/Allied costs (based on the assumptions made). However, the program can be adapted to use other scrubbing costs.

d. Coal may be shipped by rail or (where applicable) by barge on the Mississippi and/or Ohio rivers. Where appropriate rail facilities are available for storage and switching of coal cars, "unit trains" may be used for rail shipments at rates significantly below normal freight costs.

e. Specification of the availability of coal (in tons/day) at any source (mine) is optional.

f. The KELPLANS investment type LP model (5) is used to simulate the scrubbing and cleaning facilities. It uses continuous and integer variables to:

(1) represent the non-linear function that relates the cost of scrubbing with the size of the equipment by means of two linear segments. (The cost of cleaning is given to be linear with respect to the equipment size).

(2) bound the size of the scrubbing as well as cleaning systems between an upper and lower limit. (See Figures 3 and 4).

3. Nomenclature

As stated above all the variables that affect the overall cost are generated using a convenient scheme. Each category of variable that affects the system is called a class. The following discussion explains how the different variables are generated.

a. Location Codes: each geographic point in the model has been assigned a two character location code as shown in page 129. For example, the code "ME" represents Madisonville, Ky where there is a coal mine. The notation "(ML)" represents the set of all coal mines: MA, MB, ..., and MH. Similarly, the symbol "(DL)" represents the set of all power plants and "(ϕL)" represents other locations. "(PL)" is the set of all locations referenced and is equivalent to the logical union of (ML) U (DL) U (ϕL).

On page 131 under class SL, a list of the possible power plants which can have scrubbing is given. DF, for example, is a power plant in Clinton where scrubbing facilities are permitted. The last three classes (M, M2 and M3) on page 131 are used to simplify coding of the mixed integer programming in the model and are not important to this discussion.

On page 132, class CL is the list of possible cleaning locations. Class N is used to simplify the mixed integer programming in the model.

Class CST on page 133 represents all the cost factors affecting the problem.

b. Vectors: the vectors are the columns of the LP model and represent the unknowns in the problem. The vectors are:

W(ML) (DL) = tons per day of uncleaned coal shipped directly from a mine to a power plant.

WS(ML)(SL) = same as W(ML)(DL) but scrubbed at power plant (SL).

X(ML)(PL)(DL) = tons per day of uncleaned coal shipped from a mine to a power plant via some intermediate point, except where the intermediate point is at the plant or the mine.

XS(ML)(PL)(SL) = same as X(ML)(PL)(DL) but scrubbed at power plant (SL)

Y(ML)(CL)(DL) = tons per day of coal shipped from mine to transfer point (CL), cleaned at transfer point and shipped to a power plant.

YS(ML)(CL)(SL) = same as Y(ML)(CL)(DL), but scrubbed at power plant (SL)

SS1(SL) = size of scrubbing system installed at location (SL) in MMBtu/day.

SS2(SL) = variable used in KELPLAN's model to simulate the scrubbing system at location (SL). It is equivalent to [(MMBtu/day)(% Sulfur)].

S(M)(SL) = variable used in KELPLAN's model to simulate the scrubbing system at location (SL).

CC1(CL) = size of cleaning plant installed at location (CL) in tons per day of coal feed.

C(N)(CL) = same as S(M)(SL) but for cleaning system.

Q(DL) = energy deficiency, MMBtu/day

T(CST) = total cost for each cost factor (pithead, freight, etc) in $/day.

IN12(SL) or IN23(SL) = scrubbing plant indicator (integer variable). If equal to zero, plant does not exist; if equal to one, plant exists (at SL).

IM12(CL) = cleaning plant indicator (integer variable). If equal to zero, plant does not exist; if equal to one, plant exists (at CL).

RHS = right hand side which shows capacities, availabilities, etc. in units appropriate to the various equations.

The above notation W(ML)(DL) implies one variable for each combination of mine and power plant.

4. Input Data to Solve the LP Problem

The input data and the various decision variables that will affect the solution of the problem are input to the model in the form of tables. Section III has discussed in depth the sources and validity,etc. of the data that was used for this study. The following discussion covers the different tables that are used in the solving of the model. The model for Iowa consists of 18 power plants, 8 mines, 28 possible transfer plants, 8 possible scrubbing locations, and 8 possible cleaning locations. There are 142 constraints (rows), 6705 variables, and 24 integer variables.

On page 133, table RAW summarizes the properties of unwashed coal; table WASHED, the properties of clean coal. Freight handling facilities available at each location are summarized in table LOAD (page 134).

The data shown on page 135 consists of the energy requirements in table DEMAND: the sulfur specifications (different cases) are listed in table SPEC; and the miscellaneous economic factors are shown in table ECON.

On pages 136 and 137, the distances between various locations are shown. Since all locations are accessible to rail lines, the table of rail distances forms a symmetric matrix, half of which is entered as a triangular table. For locations on the Mississippi or Ohio rivers, a separate table (table RIVERD) of distances by river has been supplied (page 138).

Table COSTSCR consists of the coordinates (MSC,SIZ) used to represent the non-linear cost of scrubbing by the use of two straight lines. (See Figure 3).

Likewise, table COSTWAS consists of the coordinates (MS,SI) used to represent the cost of cleaning by one straight line (page 138). See Figure 4.

C. Solution Using KELPLANS

KELPLANS uses MAGEN(6) to generate the matrix and MPSX(7) to run the linear programming step.

Once the input data matrix has been generated, the MPSX is performed in two distinct steps. First the problem is optimixed while considering all integer variables as being continous: "continous optimum". At the continuous optimum, the integer variables which denote the existance of cleaning or scrubbing facilities (0=No , 1=Yes) may be at some intermediate value (such as 0.6). This implies that the cleaning and scrubbing costs may be understated and plant sizes may be below the feasible minimum.

In the second step, the mixed integer program (MIP) is involved to find the best solution where all of the Yes/No variables are either 0 or 1. The optimal integer solution must result in a cost equal to or greater than the continuous optimum solution.

Maximum flexibility exists in the model. The list of power plants, mines, transfer points, scrubbing and cleaning locations can be increased or decreased by adding or deleting the number in the respective class. For example, if Salix, Iowa (DN) is not a convenient location for cleaning, in class CL (page), DN must be deleted. Now, if Lansing, Iowa (DD) is a good location for scrubbing, DD should be included in class SL (page 131).

The same flexibility exists in the tables. For example, if the demand at DA has changed to 20,000 in table DEMAND (page 135) the 18,684 for DA should be changed accordingly.

Similarly, flexibility exists in the model regarding all other variables. Coal mine properties, coal costs, mine capacities, washed coal properties, transportation possiblities and costs, milages, and economic factors can all be changed as necessary to evaluate the system.

Figure 3

WET LIMESTONE SCRUBBING COST VS. CAPACITY

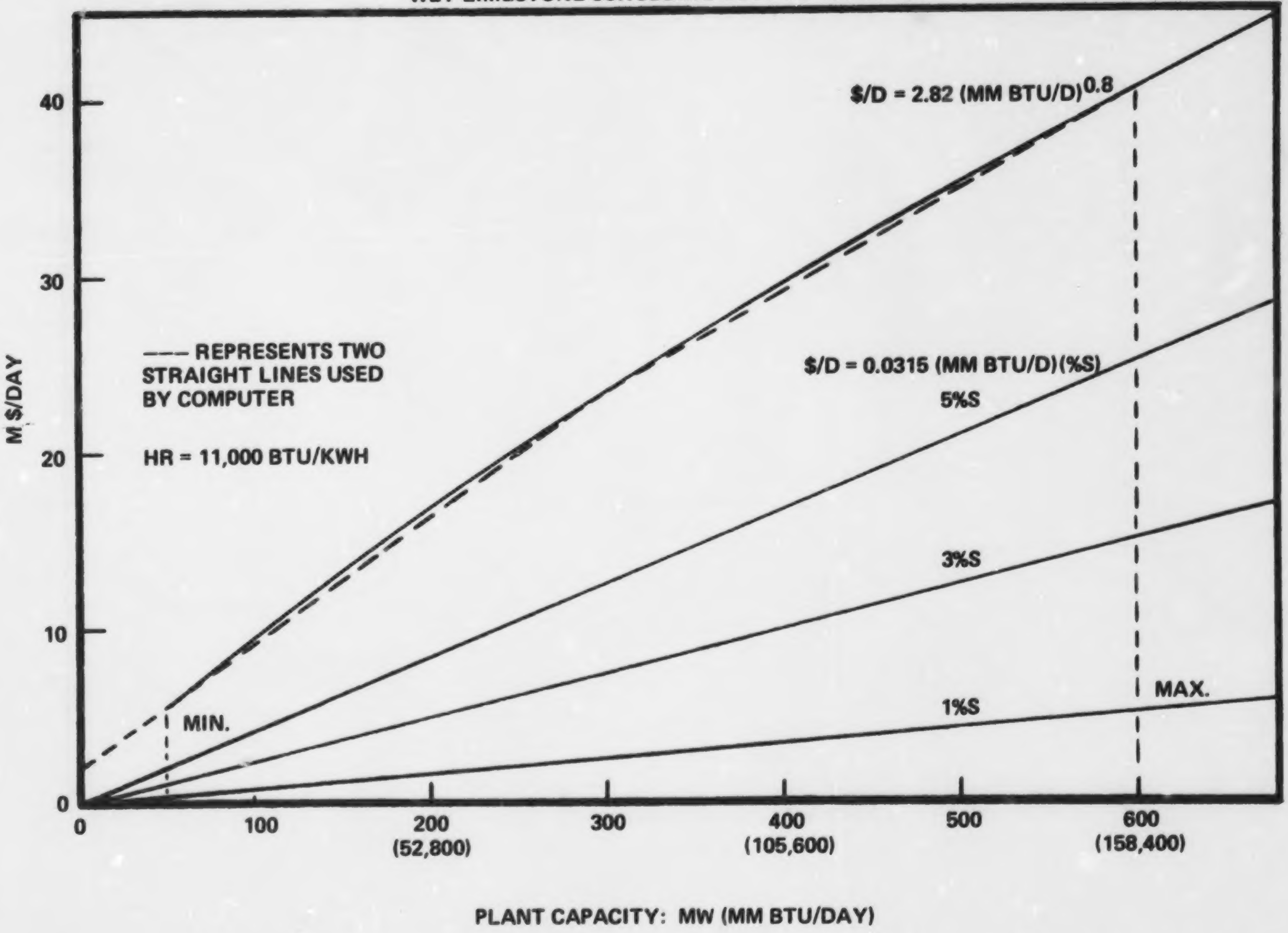
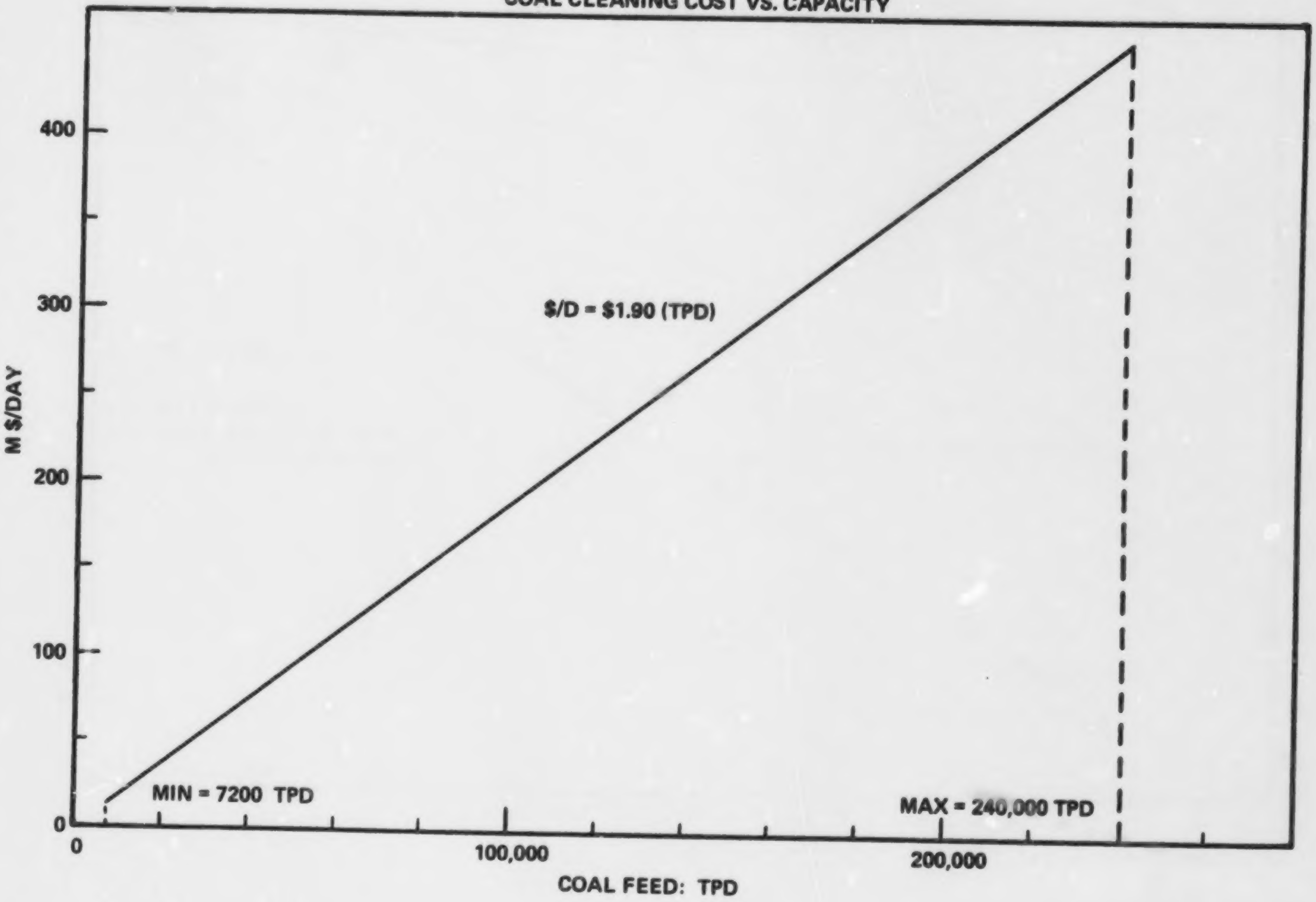


Figure 4

COAL CLEANING COST VS. CAPACITY



```
HAVERLY SYSTEMS INC LP/360 74163   VERS. J  MOD. 3   SYSTEM DATE = 3/01/74        TIME   REAL 00:00:00   TASK 00:00:00
 *                       IOWA F  MODEL
GENERATE                                                                        TIME   REAL 00:00:00   TASK 00:00:00

                                                                                TIME   REAL 00:00:00   TASK 00:00:00
      DICTIONARY


         CLASS DL
 *                        LIST OF POWER PLANT LOCATIONS
            DA    AMES (AMES MUNICIPAL PLANT)
            DB    AMES (IOWA ST U PLANT)
            DC    MONTPELIER
            DD    LANSING
            DE    DUBUQUE
            DF    CLINTON
            DG    CEDAR RAPIDS (PRAIRIE CREEK)
            DH    CEDAR RAPIDS (SIXTH ST)
            DI    MARSHALLTOWN
            DJ    BETTENDORF
            DK    COUNCIL BLUFFS
            DL    DES MOINES
            DM    WATERLOO
            DN    SALIX
            DO    EDDYVILLE
            DP    BURLINGTON
            DQ    MUSCATINE
            DR    PELLA


         CLASS ML
 *                        LIST OF COAL MINE LOCATIONS
            MA    FREDERICK IOWA
            MB    LEON IOWA
            MC    OGDEN IOWA
            MD    MARION ILLINOIS
            ME    MADISONVILLE KY
            MF    HANNA WYOMING
            MG    CRAIG COLORADO
            MH    COLSTRIP MONTANA


         CLASS OL
 *                        LIST OF OTHER POSSIBLE TRANSFER POINTS
            PA    PADUCAH KY
            PB    GORHAM  ILLINOIS


         CLASS PL
 *                        POSSIBLE LOCATIONS FOR TRANSFER POINTS
            ML)   (>)  | AT ANY MINE
           (DL)   (>)  | AT ANY POWER PLANT
```

(OL) (>) | AT ANY OTHER SPECIFIED LOCATION

```
        CLASS SL
*                 LIST OF POSSIBLE SCRUBBING LOCATIONS
           DF
           DG
           DI
           DJ
           DL
           DM
           DP
           DQ

        CLASS M
*                 LIST OF VARIABLES USED IN SCRUB. MODEL
           1
           2
           3

        CLASS M2
*                 LIST OF INTEGER VAR. SCRUB. MODEL
           12
           23

        CLASS M3
*                 LIST OF VARIABLES COST SCRUB. MODEL
           S1
           S2
```

```
     CLASS CL
*              LIST CF POSSIBLE CLEANING LOCATIONS
        DN
        DP
        MA
        MB
        MC
        MD
        PA
        PB

     CLASS N
        1
        2

     CLASS R
*              LIST OF RIGHT HAND SIDES
        1
        2
        3
        4
        CLASS CST
*                     LIST OF POSSIBLE COSTS
               PIT  PITHEAD COST
               FRT  FREIGHT COST
               ASH  ASH DISPOSAL COST
               SC1  SCRUB COST
               SC2  SCRUB COST
               WSH  WASHING PLANT COST
               REF  REFUSE DISPOSAL COST
               STO  STORAGE / LOADING / UNLOADING COSTS
               BRN  BROWNOUTS
     DATA


        TABLE RAW
*                     PROPERTIES OF UNWASHED COAL
                  ASH       SUL       BTU      CST      CAP
*
        MA        14.2      5.9      10.038    6.25     50.
        MB        12.8      4.3       9.676    6.25     50.
        MC        13.2      6.9      10.184    6.25     50.
        MD        14.9      3.1      11.951    6.70     50.
        ME        14.8      4.1      11.801    6.70     50.
        MF         8.4      0.9      10.506    4.20      8.
        MG         4.2      0.3      11.460    5.00      8.
        MH        10.0      0.8       8.790    3.60      0.
*
*                     ASH  = ASH IN WT PCT
*                     SUL  = SULFUR IN WT PCT
*                     BTU  = HEAT CONTENT IN MBTU/LB
*                     CST  = COST AT SHIPPING POINT IN $/TON
*                     CAP  = MINE CAPACITY IN MTON/DAY (BLANK=NO LIMIT)
*


        TABLE WASHED
*                     PROPERTIES OF CLEAN COAL
                  ASH       SUL       BTU      LOSS
*
        MA        7.9       3.5      11.033    20.0
        MB        7.0       1.9      10.650    20.0
        MC        7.5       4.5      11.166    20.0
        MD        7.0       2.0      12.505    20.0
        MF        7.2       2.7      12.340    20.0
*
*                     ASH,SUL,BTU = SAME AS TABLE RAW
*                     LOSS = WT PCT LOSS ON CLEANING
*
```

```
        TABLE LOAD
*                   SUMARIZES LOADING / UNLOADING FACILITIES
*                   AT EACH LOCATION    (1=YES)
                 RAIL     UNIT     BARG
*
        DA        1
        DB        1
        DC        1                 1
        DD        1                 1
        DE        1                 1
        DF        1                 1
        DG        1
        DH        1
        DI        1
        DJ        1                 1
        DK        1
        DL        1
        DM        1
        DN        1        1
        DO        1
        DP        1        1        1
        DQ        1                 1
        DR        1
*
        MA        1
        MB        1
        MC        1
        MD        1        1
        ME        1        1
        MF        1        1
        MG        1        1
        MH        1        1
*
        PA        1                 1
        PB        1                 1
*
*                  RAIL = CONVENTIONAL RAIL CAR
*                  UNIT = UNITS TRAIN
*                  BARG = BARGES
*
```

```
         TABLE DEMAND
*                      REQUIREMENT IN MMBTU/DAY
                  74
*
         DA       18684.
         DB       12994.
         DC       17726.
         DD       20023.
         DE       24504.
         DF       59525.
         DG       64862.
         DH       64937.
         DI       43219.
         DJ       67512.
         DK       33461.
         DL       87017.
         DM       31570.
         DN      115682.
         DO       25608.
         DP       51307.
         DQ       31488.
         DR       18259.


         TABLE SPEC
*                      SPEC IN LBS SO2 / MMBTU
                  MUX
*
         1        20.
         2         5.
         3         3.1
         4         1.2


         TABLE ECON
*                      ECONOMIC FACTORS
                 TON      TPM      TPH
*               $/TON    $/T/M    $/T/HR
*
         RAIL              0.028
         UNIT              0.005
         BARG              0.006
*
         ASHE    1.
         REFU    0.31
         STOR    0.30
*
         FINV                       1.0
         CINV                       1.0
*
         CBRN    10000.
```

```
      TABLE RRDIST
                 DISTANCES BY RAIL
           DA      DB      DC      DD      DE      DF      DG      DH

     DA
     DB      3
     DC    187     187
     DD    244     244     190
     DE    177     177     109      81
     DF    187     187      48     142      61
     DG    105     105      82     170      89      82
     DH    105     105      82     170      89      82       5
     DI     37      37     150     188     140     150      68      68
     DJ    183     183      16     174      93      32      78      78
     DK    155     155     302     355     331     342     260     260
     DL     36      35     182     247     201     206     124     124
     DM     85      85     134     140      94     134      52      52
     DN    192     192     385     390     344     379     297     297
     DO    111     111     111     277     196     159     107     107
     DP    201     201      75     265     184     123      98      98
     DQ    173     173      14     204     123      62      68      68
     DR     83      83     139     305     224     187     135     135
     MA    117     117     117     283     202     165     113     113
     MB    125     125     187     353     272     235     183     183
     MC     22      22     209     266     199     209     127     127
     MD    502     502     371     535     454     393     436     436
     ME    596     596     465     629     548     487     530     530
     MF    795     795     942     995     971     982     900     900
     MG    943     943    1090    1143    1119    1130    1048    1048
     MH    915     915    1018    1019    1043    1094    1012    1012
     PA    549     549     418     582     501     440     480     480
     PB    463     463     332     496     415     354     394     394

           DI      DJ      DK      DL      DM      DN      DO      DP

     DJ    146
     DK    192     318
     DL     59     178     161
     DM     48     130     237     107
     DN    229     375      83     208     250
     DO     67     127     197      75     115     283
     DP    157      91     281     165     150     370      90
     DQ    138      30     288     168     120     380      97      61
     DR     74     155     225      47     122     255      28     118
     MA     73     133     191      81     121     289       6      96
     MB    148     203     244      89     196     297      82     166
     MC     59     205     133      58     107     170     133     223
     MD    480     361     539     466     488     622     413     338
     ME    574     455     633     560     582     716     507     432
     MF    832     958     640     801     877     682     837     921
     MG    980    1106     788     949    1025     859     985    1069
     MH    951    1090     870     950     960     787    1025    1110
     PA    527     408     586     513     532     669     460     385
     PB    441     322     500     427     446     583     374     299

           DQ      DR      MA      MB      MC      MD      ME      MF

     DR    125
```

136

```
MA    103     34
MB    173    110     76
MC    195    105    139    145
MD    385    441    407    438    518
ME    479    535    501    532    612    145
MF    928    865    831    884    773   1179   1273
MG   1076   1013    979   1032    921   1347   1421    557
MH   1080    997   1031   1039    929   1429   1503    887
PA    432    488    454    485    565     54     85   1226
PB    346    402    368    399    479     40    185   1140

+            MG     MH     PA     PB
*
MH   1034
PA   1374   1456
PB   1288   1370    100
```

```
       TABLE RIVERD
*                   DISTANCES BY RIVER
              DC    DD    DE    DF    DJ    DP    DQ    PA    PB
*
       DC
       DD    188
       DE    108    80
       DF     48   140    60
       DJ     18   170    90    30
       DP     67   255   175   115    85
       DQ     17   205   125    65    35    50
       PA    516   704   624   564   534   449   499
       PB    386   574   494   434   404   319   369   130


       TABLE COSTSCR
*                   INCLUDES PARAMETERS NEEDED TO
*                   MODEL THE NON-LINEAR PART OF
*                   THE COST OF SCRUBBING
           MSC        SIZ
*
       1   5581.     -13200.
       2  23400.     -79200.
       3  40740.    -158400.


       TABLE COSTWAS
*                   INCLUDES PARAMETERS NEEDED TO
*                   MODEL THE COST OF WASHING
*
           MS              SZ
       1   13680.         -7200.
       2   456000.        -240000.
```

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IX. GLOSSARY

acfm : Flow rate in actual cubic feet per minute (measured at flowing conditions)

Btu : Energy measured in British Thermal Units

load factor : Fraction which multiplied by peak generating capacity gives the average generating capacity for the year.

csa : Cross-sectional area

cu yd : Volume measured in cubic yards

ESP : Electrostatic Precipitator

°F : Temperature in degrees Farenheit

FPC : Federal Power Commission

ft : Linear measure in feet

fps : Velocity in feet per second

sq ft : Area in square feet

gal : Volume measured in U.S. Gallons (7.481 gallons = one cubic foot)

gpm : Flow rate measured in gallons per minute

grain : Mass equal to 1/7000 of one pound

hr : Time in hours

"H_2O : Pressure in inches of water (27.72 inches of water = 1 pound per square inch)

kv : 1,000 volts

kw : Power measured in kilowatts (1 kw = 1,000 watts)

kwh : Energy measured in kilowatt-hours

long ton (LT) : Mass (1 long ton = 2240 pounds

M : 1,000 units (e.g. M$ = thousands of dollars)

MM : 1,000,000 units

mw : Power measured in megawatts (1 mw = 1,000,000 watts or 1,000 kilowatts

ppm : Concentration measured in parts per million (by volume)

psia : Pressure in pounds per square inch absolute

psig : Pressure in pounds per square inch gage

lb/hr : Flow rate measured in pounds per hour

scfm : Flow rate in standard cubic feet per minute (measured at 60°F and 14.7 psia)

sec : Time in seconds

ton : Mass (1 ton = 2,000 pounds)

tph : Flow rate measured in tons per hour

X. APPENDICES

APPENDIX A

POWER PLANT INPUT DATA

Table 5

Power Plant Input Data

Des Moines Plant

Iowa Power & Light Company

General Plant Design Data

Plant Location	Des Moines, Iowa
Plant Capacity, MW	325
No. of Boilers	6
No. of Generators	7

Coal Data(1)

Source	Iowa, Illinois, Wyoming	
Method of Transportation	Rail, Truck	
Moisture, %	16.9	
Ash, %	15.2	
Sulfur, %	4.1	Max. Monthly Avg. 4.7
Heating Value, Btu/lb.	9395	

Plant Operating Data in 1972

Plant Average Heat Rate, Btu/KWH	11,156
Plant Average Load Factor, %	58.5

Des Moines Plant

Table 5

Power Plant Input Data

Boiler Data[2]	Boiler No. 6	Boiler No. 7	Boiler No. 8	Boiler No. 9
Turbo-Generating Capacity, MW	136 Mw for 4 boilers through common headers			
Coal Consumption, TPH	Stand-by oil)	24	24	24
Air Flow				
Total Air, SCFM	87,500	52,000	52,000	52,000
Excess Air, %	7	10 - 30	10 - 30	10 - 30
Flue Gas Flow, ACFM	253,000	173,000	173,000	178,000
Flue Gas Temperature, °F	330	330	330	350
Boiler Efficiency, %	83.2	82.3	82.3	82.3
Total Hours Operation During 1972	6,881	7,398	6,425	7,210
Average Capacity Factor, %	52	52	52	52
Year Boiler Placed in Service	1964	1938	1949	1950
Remaining Life of Unit, Yrs. (based on 40 year life)	30	4	15	16
Related to Generator No.	1 - 5	1 - 5	1 - 5	1 - 5
Served by Stack No.	1	2	2	3

Des Moines Plant

Table 5
Power Plant Input Data

Boiler Data(2)	Boiler No. 10	Boiler No. 11	Boiler No.	Boiler No.
Turbo-Generating Capacity, MW	70	110		
Coal Consumption, TPH	42	50		
Air Flow				
Total Air, SCFM	79,500	109,000		
Excess Air, %	23	19		
Flue Gas Flow, ACFM	283,000	343,000		
Flue Gas Temperature, °F	343	290		
Boiler Efficiency, %	86.5	88.4		
Total Hours Operation During 1972	6,134	7,854		
Average Capacity Factor, %	80	71		
Year Boiler Placed in Service	1954	1964		
Remaining Life of Unit, Yrs. (based on 40 year life)	20	30		
Related to Generator No.	6	7		
Served by Stack No.	4	5		

Des Moines Plant

Table 5

Power Plant Input Data

Boiler Data (Cont'd)	Boiler No. 6	Boiler No. 7	Boiler No. 8	Boiler No. 9
Stack Height, Ft. above grade	138	250	250	250
I.D. of Flue at Top, Ft.	15	10	10	10
Distance to ℄ of Stack Breeching, Ft. above grade	80	105	105	105
Fly Ash Removal Equipment				
Type	None	Cyclones	Cyclones	Cyclones
Design Efficiency, %	-	65	65	65
Scheduled Maintenance Shutdown				
Interval, Months	24	18	18	18
Duration, Weeks	3	5	5	5

(1) Coal quality and heating value are average values for coal burned in 1972.

(2) Operating data are at 100% load

Des Moines Plant

Table 5

Power Plant Input Data

Boiler Data (Cont'd)	Boiler No. 10	Boiler No. 11	Boiler No	Joiler No.
Stack Height, Ft. above grade	250	250		
I.D. of Flue at Top, Ft.	12	10		
Distance to ℄ of Stack Breeching, Ft. above grade	23	14		
Fly Ash Removal Equipment				
Type	ESP	ESP		
Design Efficiency, %	99.3	99.3		
Scheduled Maintenance Shutdown				
Interval, Months	12	12		
Duration, Weeks	4	4		

(1) Coal quality and heating value are average values for coal burned in 1972.

(2) Operating data are at 100% load

Des Moines Plant

Table 6
Stack Gas Scrubbing System

	Boiler No. 7,8	Boiler No. 9	Boiler No. 10	Boiler No. 11	Boiler No.
Scrubbing System					
No. Scrubbing Trains Required	1	1	1	1	
Train Size[1]	IV	VI	V	III	
Train Type					
Wet Limestone	C	C	C	A	
Wellman-Lord	A	A	A	A	
Limestone System					
Max. Design Capacity : tph	48.1				
Wellman-Lord/Allied System					
Sulfur Flow : lb./hr.	18,000				
Regeneration Area : No. Trains Required	2				
Size[2]	I				
Purge/Make-up Area : No. Trains Required	1				
Size[2]	I				
SO_2 Reduction Area : No. Trains Required	1				
Size[2]	I				

(1) Refers to standard size scrubber modules.

(2) Refers to standard size modules.

Table 7

Power Plant Input Data

Maynard Plant

Iowa Public Service Co.

General Plant Design Data

Plant Location	Waterloo, Iowa
Plant Capacity, MW	107
No. of Boilers	5
No. of Generators	4

Coal Data(1)

Source	Illinois	
Method of Transportation	Rail	
Moisture, %	12.0	
Ash, %	11.0	
Sulfur, %	2.5	Max. Monthly Avg. 2.8
Heating Value, Btu/lb.	10,861	

Plant Operating Data in 1972

Plant Average Heat Rate, Btu/KWH	12,293
Plant Average Load Factor, %	40.0

Maynard Plant

Table 7
Power Plant Input Data

Boiler Data(2)	Boiler No.9	Boiler No.10	Boiler No.11	Boiler No.12
Turbo-Generating Capacity, MW	12		12	25
Coal Consumption, TPH	6	6	6	0 (Oil & gas)
Air Flow				
Total Air, SCFM	55,900	52,200	52,900	62,900
Excess Air, %	118	95	95	35
Flue Gas Flow, ACFM	102,000	95,000	84,000	101,000
Flue Gas Temperature, °F	400	393	403	300
Boiler Efficiency, %	83	83	83	85
Total Hours Operation During 1972	2,286	721	2,838	4,054
Average Capacity Factor, %	18.4	5.7	25.2	26.0
Year Boiler Placed in Service	1937	1943	1947	1951
Remaining Life of Unit, Yrs. (based on 40 year life)	3	9	13	17
Related to Generator No.	4	4.5	5	6
Served by Stack No.	2	2	1	2

Maynard Plant

Table 7
Power Plant Input Data

Boiler Data[2]	Boiler No. 14	Boiler No.	Boiler No.	Boiler No.
Turbo-Generating Capacity, MW	58			
Coal Consumption, TPH	24			
Air Flow				
Total Air, SCFM	132,300			
Excess Air, %	25			
Flue Gas Flow, ACFM	373,000			
Flue Gas Temperature, °F	325			
Boiler Efficiency, %	87			
Total Hours Operation During 1972	8,085			
Average Capacity Factor, %	66.6			
Year Boiler Placed in Service	1958			
Remaining Life of Unit, Yrs. (based on 40 year life)	24			
Related to Generator No.	7			
Served by Stack No.	3			

Maynard Plant

Table 7

Power Plant Input Data

Boiler Data (Cont'd)	Boiler No. 9	Boiler No. 10	Boiler No. 11	Boiler No. 12
Stack Height, Ft. above grade	220	220	220	Common stack for Units 9,10,12
I.D. of Flue at Top, Ft.				
Distance to ℄ of Stack Breeching, Ft. above grade	69' 0" above basement floor		23' 3"	69' 0" above basement floor
Fly Ash Removal Equipment				
Type	Cyclones	Cyclones	Cyclones	None
Design Efficiency, %	88	88	88	--
Scheduled Maintenance Shutdown				
Interval, Months	12	12	12	12
Duration, Weeks	2	2	2	2

(1) Coal quality and heating value are average values for coal burned in 1972.

(2) Operating data are at 100% load

Maynard Plant

Table 7

Power Plant Input Data

Boiler Data (Cont'd)	Boiler No. 14	Boiler No.	Boiler No.	Boiler No.
Stack Height, Ft. above grade	250			
I.D. of Flue at Top, Ft.				
Distance to ℄ of Stack Breeching, Ft. above grade	30			
Fly Ash Removal Equipment				
Type	ESP			
Design Efficiency, %	99			
Scheduled Maintenance Shutdown				
Interval, Months	12			
Duration, Weeks	2			

(1) Coal quality and heating value are average values for coal burned in 1972.

(2) Operating data are at 100% load

Maynard Plant

Table 8
Stack Gas Scrubbing System

	Boiler No.9,10,12	Boiler No.11	Boiler No.14	Boiler No.	Boiler No.
Scrubbing System					
No. Scrubbing Trains Required	1	1	1		
Train Size(1)	IV	VIII	III		
Train Type					
Wet Limestone	C	C	C		
Wellman-Lord	A	A	A		
Limestone System					
Max. Design Capacity : tph	7.9				
Wellman-Lord/Allied System					
Sulfur Flow : lb./hr.	3030				
Regeneration Area : No. Trains Required	1				
Size(2)	VII				
Purge/Make-up Area : No. Trains Required	1				
Size(2)	VII				
SO_2 Reduction Area : No. Trains Required	1				
Size(2)	VII				

(1) Refers to standard size scrubber modules.

(2) Refers to standard size modules.

Table 9

Power Plant Input Data

Muscatine Plant

Muscatine Municipal Electric Plant

General Plant Design Data

Plant Location	Muscatine, Iowa
Plant Capacity, MW	117
No. of Boilers	4
No. of Generators	4

Coal Data(1)

Source	Illinois
Method of Transportation	Barge, Rail
Moisture, %	16.4
Ash, %	10.2
Sulfur, %	3.0 Max. Monthly Avg. 3.2
Heating Value, Btu/lb.	10,899

Plant Operating Data in 1972

Plant Average Heat Rate, Btu/KWH	11,214
Plant Average Load Factor, %	57.9

Muscatine Plant

Table 9

Power Plant Input Data

Boiler Data(2)	Boiler No. 5	Boiler No. 6	Boiler No. 7	Boiler No. 8
Turbo-Generating Capacity, MW	7.5 (Standby)	12.5 (Peaking)	22 (Base Load)	84 (Base Load)
Coal Consumption, TPH	4.5	7	11.5	84
Air Flow				
Total Air, SCFM				130,000 Est
Excess Air, %	30	30	20	11.5
Flue Gas Flow, ACFM	25,000 (Est.)	40,000 (Est)	70,000 (Est.)	251,000
Flue Gas Temperature, °F	360	380	340	322
Boiler Efficiency, %	80	80	84	90.3
Total Hours Operation During 1972	2000	4000	7300 (Est.)	8000
Average Capacity Factor, %	50	50	70	90
Year Boiler Placed in Service	1941	1946	1958	1969
Remaining Life of Unit, Yrs. (based on 40 year life)	7	12	24	35
Related to Generator No.	5 or 6	5 or 6	7	8
Served by Stack No.	2(3)	1(3)	3(3)	4

Muscatine Plant

Table 9

Power Plant Input Data

Boiler Data(Cont'd)	Boiler No. 5	Boiler No. 6	Boiler No. 7	Boiler No. 8
Stack Height, Ft. above grade	115[(3)]	115[(3)]	115[(3)]	320
I.D. of Flue at Top, Ft.	7	7	6'-8"	8'-6"
Distance to ℄ of Stack Breeching, Ft. above grade (Grade = 95'-0") (Basement Floor)	86	86	120	200
Fly Ash Removal Equipment				
Type	Mech. (May, 1975)	Mech(May,1975)	Mech(ESP May,1975)	ESP
Design Efficiency, %	80	80	80 & 90	95
Scheduled Maintenance Shutdown				
Interval, Months	Varies (Due to	Varies (Due to	6	6
Duration, Weeks	20-26 Peaking)	20-26 Peaking)	1	1

(1) Coal quality and heating value are average values for coal burned in 1972.

(2) Operating data are at 100% load

(3) Units 5, 6, and 7 will be served by one new stack, 220' high.

Muscatine Plant

Table 10
Stack Gas Scrubbing System

	Boiler No.5,6,7	Boiler No.8	Boiler No.	Boiler No.	Boiler No.
Scrubbing System					
No. Scrubbing Trains Required	1	1			
Train Size(1)	VII	V			
Train Type					
Wet Limestone	A	A			
Wellman-Lord	A	A			
Limestone System					
Max. Design Capacity : tph	9.0				
Wellman-Lord/Allied System					
Sulfur Flow : lb./hr.	3610				
Regeneration Area : No. Trains Required	1				
Size(2)	VI				
Purge/Make-up Area : No. Trains Required	1				
Size(2)	VI				
SO_2 Reduction Area : No. Trains Required	1				
Size(2)	VI				

(1) Refers to standard size scrubber modules.

(2) Refers to standard size modules.

Table 11

Power Plant Input Data

Riverside Plant

Iowa-Illinois Gas & Electric Company

General Plant Design Data

Plant Location	Bettendorf, Iowa
Plant Capacity, MW	222
No. of Boilers	5
No. of Generators	5

Coal Data(1)

Source	Illinois	
Method of Transportation	Rail	
Moisture, %	16.8	
Ash, %	8.7	
Sulfur, %	2.6	Max. Monthly Avg. 2.9
Heating Value, Btu/lb.	10,420	

Plant Operating Data in 1972

Plant Average Heat Rate, Btu/KWH	12,671
Plant Average Load Factor, %	66.2

Riverside Plant

Table 11
Power Plant Input Data

Boiler Data[2]	Boiler No. 5	Boiler No. 6	Boiler No. 7	Boiler No. 8
Turbo-Generating Capacity, MW	16	20	22	22
Coal Consumption, TPH	13.1	14.8	14.4	14.4
Air Flow				
Total Air, SCFM	47,000	52,000	51,000	51,000
Excess Air, %	5	5	5	5
Flue Gas Flow, ACFM	99,100	103,000	91,000	91,000
Flue Gas Temperature, °F	373	375	300 Est	300 Est
Boiler Efficiency, %	84.2	83.8	85.0	85.0
Total Hours Operation During 1972	5,295	7,419	6,941	7,281
Average Capacity Factor, %	40.9	54.4	54.0	56.0
Year Boiler Placed in Service	1937	1944	1949	1949
Remaining Life of Unit, Yrs. (based on 40 year life)	3	10	15	15
Related to Generator No.	3	3	4	4
Served by Stack No.	5	6	9	9

Riverside Plant

Table 11
Power Plant Input Data

Boiler Data(2)	Boiler No. 9	Boiler No.	Boiler No.	Boiler No.
Turbo-Generating Capacity, MW	140			
Coal Consumption, TPH	61.5			
Air Flow				
Total Air, SCFM	221,000			
Excess Air, %	5			
Flue Gas Flow, ACFM	389,000			
Flue Gas Temperature, °F	297			
Boiler Efficiency, %	87.4			
Total Hours Operation During 1972	7,074			
Average Capacity Factor, %	62.8			
Year Boiler Placed in Service	1961			
Remaining Life of Unit, Yrs. (based on 40 year life)	27			
Related to Generator No.	5			
Served by Stack No.	9			

Riverside Plant

Table 11

Power Plant Input Data

Boiler Data (Cont'd)	Boiler No. 5	Boiler No. 6	Boiler No7	Boiler No.8
Stack Height, Ft. above grade	144	144	346	346
I.D. of Flue at Top, Ft.	8'-6"	8'-6"	13'-4"	13'-4"
Distance to ℄ of Stack Breeching, Ft. above grade (Grade = El 95'-6")				
Fly Ash Removal Equipment				
Type	ESP	ESP	ESP	ESP
Design Efficiency, %	99.1	99.1	99.2	99.2
Scheduled Maintenance Shutdown				
Interval, Months	12 - 14	12 - 14	12 - 14	12 - 14
Duration, Weeks	2 - 4	2 - 4	2 - 4	2 - 4

(1) Coal quality and heating value are average values for coal burned in 1972.

(2) Operating data are at 100% load

Riverside Plant

Table 11

Power Plant Input Data

Boiler Data (Cont'd)	Boiler No. 9	Boiler No.	Boiler No	Boiler No.
Stack Height, Ft. above grade	346			
I.D. of Flue at Top, Ft.	13'-4"			
Distance to ℄ of Stack Breeching, Ft. above grade				
Fly Ash Removal Equipment				
Type	ESP			
Design Efficiency, %	99.2			
Scheduled Maintenance Shutdown				
Interval, Months	12 - 14			
Duration, Weeks	2 - 4			

(1) Coal quality and heating value are average values for coal burned in 1972.

(2) Operating data are at 100% load

Riverside Plant

Table 12
Stack Gas Scrubbing System

	Boiler No.5,6	Boiler No.7,8	Boiler No.9	Boiler No.	Boiler No.
Scrubbing System					
No. Scrubbing Trains Required	1	1	1		
Train Size[1]	V	V	II		
Train Type					
Wet Limestone	C	A	A		
Wellman-Lord	A	A	A		
Limestone System					
Max. Design Capacity : tph	18.3				
Wellman-Lord/Allied System					
Sulfur Flow : lb./hr.	7020				
Regeneration Area : No. Trains Required	1				
Size[2]	III				
Purge/Make-up Area : No. Trains Required	1				
Size[2]	IV				
SO_2 Reduction Area : No. Trains Required	1				
Size[2]	IV				

(1) Refers to standard size scrubber modules.

(2) Refers to standard size modules.

Table 13

Power Plant Input Data

Burlington Plant

Iowa-Southern Utilities Co.

General Plant Design Data

Plant Location	Burlington, Iowa
Plant Capacity, MW	212
No. of Boilers	1
No. of Generators	1

Coal Data[1]

Source	Illinois	
Method of Transportation	Rail	
Moisture, %	20.5	
Ash, %	8.2	
Sulfur, %	2.6	Max. Monthly Avg. 3.0
Heating Value, Btu/lb.	10,136	

Plant Operating Data in 1972

Plant Average Heat Rate, Btu/KWH	10,084
Plant Average Load Factor, %	59.2

Burlington Plant

Table 13

Power Plant Input Data

Boiler Data[2]	Boiler No. 1	Boiler No.	Boiler No.	Boiler No.
Turbo-Generating Capacity, MW	212			
Coal Consumption, TPH	89.2			
Air Flow				
Total Air, SCFM	348,000			
Excess Air, %	20			
Flue Gas Flow, ACFM	644,000			
Flue Gas Temperature, °F	261			
Boiler Efficiency, %	86.4			
Total Hours Operation During 1972	8,180			
Average Capacity Factor, %	59.2			
Year Boiler Placed in Service	1968			
Remaining Life of Unit, Yrs. (based on 40 year life)	34			
Related to Generator No.	1			
Served by Stack No.	1			

Burlington Plant

Table 13

Power Plant Input Data

Boiler Data (Cont'd)	Boiler No. 1	Boiler No.	Boiler No	Boiler No.
Stack Height, Ft. above grade	306			
I.D. of Flue at Top, Ft.	11' 9"			
Distance to ℄ of Stack Breeching, Ft. above grade	∿140'			
Fly Ash Removal Equipment				
Type	ESP			
Design Efficiency, %	98.5			
Scheduled Maintenance Shutdown				
Interval, Months	12			
Duration, Weeks	2			

(1) Coal quality and heating value are average values for coal burned in 1972.

(2) Operating data are at 100% load

Burlington Plant

Table 14
Stack Gas Scrubbing System

	Boiler No.1	Boiler No.	Boiler No.	Boiler No.	Boiler No.
Scrubbing System					
No. Scrubbing Trains Required	2				
Train Size[1]	III				
Train Type					
Wet Limestone	A				
Wellman-Lord	A				
Limestone System					
Max. Design Capacity : tph	12.8				
Wellman-Lord/Allied System					
Sulfur Flow : lb./hr.	5480				
Regeneration Area : No. Trains Required	1				
Size[2]	V				
Purge/Make-up Area : No. Trains Required	1				
Size[2]	V				
SO_2 Reduction Area : No. Trains Required	1				
Size[2]	V				

(1) Refers to standard size scrubber modules.

(2) Refers to standard size modules.

Table 15

Power Plant Input Data

Kapp Plant

Interstate Power Company

General Plant Design Data

Plant Location	Clinton, Iowa
Plant Capacity, MW	237
No. of Boilers	2
No. of Generators	2

Coal Data(1)

Source	Illinois
Method of Transportation	Barge, Rail
Moisture, %	11.8
Ash, %	11.0
Sulfur, %	3.1 Max. Monthly Avg. 3.3
Heating Value, Btu/lb.	10,981

Plant Operating Data in 1972

Plant Average Heat Rate, Btu/KWH	10,465
Plant Average Load Factor, %	59.8

Kapp Plant

Table 15

Power Plant Input Data

Boiler Data(2)	Boiler No. 1	Boiler No. 2	Boiler No.	Boiler No.
Turbo-Generating Capacity, MW	19	218		
Coal Consumption, TPH	11.1	92		
Air Flow				
Total Air, SCFM	45,000	410,000		
Excess Air, %	25	18		
Flue Gas Flow, ACFM	80,000	634,000		
Flue Gas Temperature, °F	355	289		
Boiler Efficiency, %	84.9	87.0		
Total Hours Operation During 1972	6406	8070		
Average Capacity Factor, %	52	71		
Year Boiler Placed in Service	1947	1967		
Remaining Life of Unit, Yrs. (based on 40 year life)	13	33		
Related to Generator No.	1	2		
Served by Stack No.	1	2		

Kapp Plant

Table 15

Power Plant Input Data

Boiler Data (Cont'd)	Boiler No.1	Boiler No. 2	Boiler No.	Boiler No.
Stack Height, Ft. above grade	210	245		
I.D. of Flue at Top, Ft.	9	13		
Distance to ℄ of Stack Breechirg, Ft. above grade	25	37		
Fly Ash Removal Equipment				
Type	None (3)	ESP		
Design Efficiency, %	-	98.0		
Scheduled Maintenance Shutdown				
Interval, Months	6	6		
Duration, Weeks	2	2		

(1) Coal quality and heating value are average values for coal burned in 1972.

(2) Operating data are at 100% load

(3) A new ESP for No.1 will be on stream in early 1975.

Kapp Plant

Table 16
Stack Gas Scrubbing System

	Boiler No.1	Boiler No.2	Boiler No.	Boiler No.	Boiler No.
Scrubbing System					
No. Scrubbing Trains Required	1	2			
Train Size(1)	VIII	IV			
Train Type					
Wet Limestone	C	C			
Wellman-Lord	A	A			
Limestone System					
Max. Design Capacity : tph	17.4				
Wellman-Lord/Allied System					
Sulfur Flow : lb./hr.	6780				
Regeneration Area : No. Trains Required	1				
Size(2)	III				
Purge/Make-up Area : No. Trains Required	1				
Size(2)	IV				
SO_2 Reduction Area : No. Trains Required	1				
Size(2)	IV				

(1) Refers to standard size scrubber modules.

(2) Refers to standard size modules.

Table 17
Power Plant Input Data
Prairie Creek Plant
Iowa Electric Light & Power Co. & Central Iowa Power Cooperative (Units 1,2,3)

General Plant Design Data

Plant Location	Cedar Rapids, Iowa
Plant Capacity, MW	245
No. of Boilers	4
No. of Generators	4

Coal Data(1)

Source	Illinois
Method of Transportation	Rail
Moisture, %	16.9
Ash, %	8.5
Sulfur, %	2.5 Max. Monthly Avg. 3.1
Heating Value, Btu/lb.	10,473

Plant Operating Data in 1972

Plant Average Heat Rate, Btu/KWH	11,031
Plant Average Load Factor, %	53.5

Table 17

Power Plant Input Data

Boiler Data(2)	Boiler No. 1	Boiler No. 2	Boiler No. 3	Boiler No. 4
Turbo-Generating Capacity, MW	23.5	23.5	49.5	149
Coal Consumption, TPH	12.5	12.5	25.5	62
Air Flow				
Total Air, SCFM	48,200	48,200	104,200	266,600
Excess Air, %	25	25	22	20
Flue Gas Flow, ACFM	200,000		183,000	448,000
Flue Gas Temperature, °F	344	344	313	284
Boiler Efficiency, %	83	83	85	87
Total Hours Operation During 1972	5,831	5,970	8,010	7,388
Average Capacity Factor, %	47.9	51.1	60.8	59.4
Year Boiler Placed in Service	1950	1950	1958	1967
Remaining Life of Unit, Yrs. (based on _____ year life)	16	16	24	33
Related to Generator No.	1	2	3	4
Served by Stack No.	1	1	2	3

Prairie Creek Plant

Table 17

Power Plant Input Data

Boiler Data (Cont'd)	Boiler No. 1	Boiler No. 2	Boiler No. 3	Boiler No. 4
Stack Height, Ft. above grade	180	180	180	200
I.D. of Flue at Top, Ft.	16	16	13	13
Distance to ℄ of Stack Breeching, Ft. above grade	80	80	115	35
Fly Ash Removal Equipment				
Type	Multiple Cyclones	Multiple Cyclones	ESP	MCTA(3)
Design Efficiency, %	85	85	98.6	80
Scheduled Maintenance Shutdown				
Interval, Months	12	12	12	12
Duration, Weeks	3	3	3	3

(1) Coal quality and heating value are average values for coal burned in 1972.

(2) Operating data are at 100% load

(3) A new ESP for Unit 4 will be on stream in October, 1974.

Prairie Creek Plant

Table 18
Stack Gas Scrubbing System

	Boiler No.1, 2	Boiler No.3	Boiler No. 4	Boiler No.	Boiler No.
Scrubbing System					
No. Scrubbing Trains Required	1	1	1		
Train Size[(1)]	IV	IV	I		
Train Type					
Wet Limestone	C	C	A		
Wellman-Lord	A	A	A		
Limestone System					
Max. Design Capacity : tph	18.7				
Wellman-Lord/Allied System					
Sulfur Flow : lb./hr.	6450				
Regeneration Area : No. Trains Required	1				
Size[(2)]	III				
Purge/Make-up Area : No. Trains Required	1				
Size[(2)]	IV				
SO_2 Reduction Area : No. Trains Required	1				
Size[(2)]	IV				

(1) Refers to standard size scrubber modules.

(2) Refers to standard size modulas.

Table 19

Power Plant Input Data

Sutherland Plant

Iowa Electric Light & Power Co.

General Plant Design Data

Plant Location	Marshalltown, Iowa.	
Plant Capacity, MW	157	
No. of Boilers	3	
No. of Generators	3	

Coal Data(1)

Source		
Method of Transportation	Rail	
Moisture, %	16.0	
Ash, %	11.7	
Sulfur, %	2.8	Max. Monthly Avg. 3.2
Heating Value, Btu/lb.	10,124	

Plant Operating Data in 1972

Plant Average Heat Rate, Btu/KWH	11,470
Plant Average Load Factor, %	73.5

Sutherland Plant

Table 19
Power Plant Input Data

Boiler Data(2)	Boiler No. 1	Boiler No. 2	Boiler No. 3	Boiler No.
Turbo-Generating Capacity, MW	37.5	37.5	81.6	
Coal Consumption, TPH	21	21	42	
Air Flow				
Total Air, SCFM	76,500	76,500	160,000	
Excess Air, %	22	22	16	
Flue Gas Flow, ACFM	137,000	137,000	269,000	
Flue Gas Temperature, °F	325	325	335	
Boiler Efficiency, %	85	85	88	
Total Hours Operation During 1972	8,424	7,920	7,752	
Average Capacity Factor, %	76.6	71. 5	81.4	
Year Boiler Placed in Service	1955	1955	1961	
Remaining Life of Unit, Yrs. (based on 40 year life)	21	21	27	
Related to Generator No.	1	2	3	
Served by Stack No.	1	2	3	

Sutherland Plant

Table 19

Power Plant Input Data

Boiler Data (Cont'd)	Boiler No. 1	Boiler No. 2	Boiler No 3	Boiler No.
Stack Height, Ft. above grade	190	190	190	
I.D. of Flue at Top, Ft.	8'	8'	10'-6"	
Distance to ℄ of Stack Breeching, Ft. above grade	133'	133'	156'	
Fly Ash Removal Equipment(3)				
Type	MCTA	MCTA	MCTA	
Design Efficiency, %	80	80	80	
Scheduled Maintenance Shutdown				
Interval, Months	12	12	12	
Duration, Weeks	3	3	3	

(1) Coal quality and heating value are average values for coal burned in 1972.
(2) Operating data are at 100% load
(3) New ESP's are being installed on all boilers by early 1975.

Sutherland Plant

Table 20
Stack Gas Scrubbing System

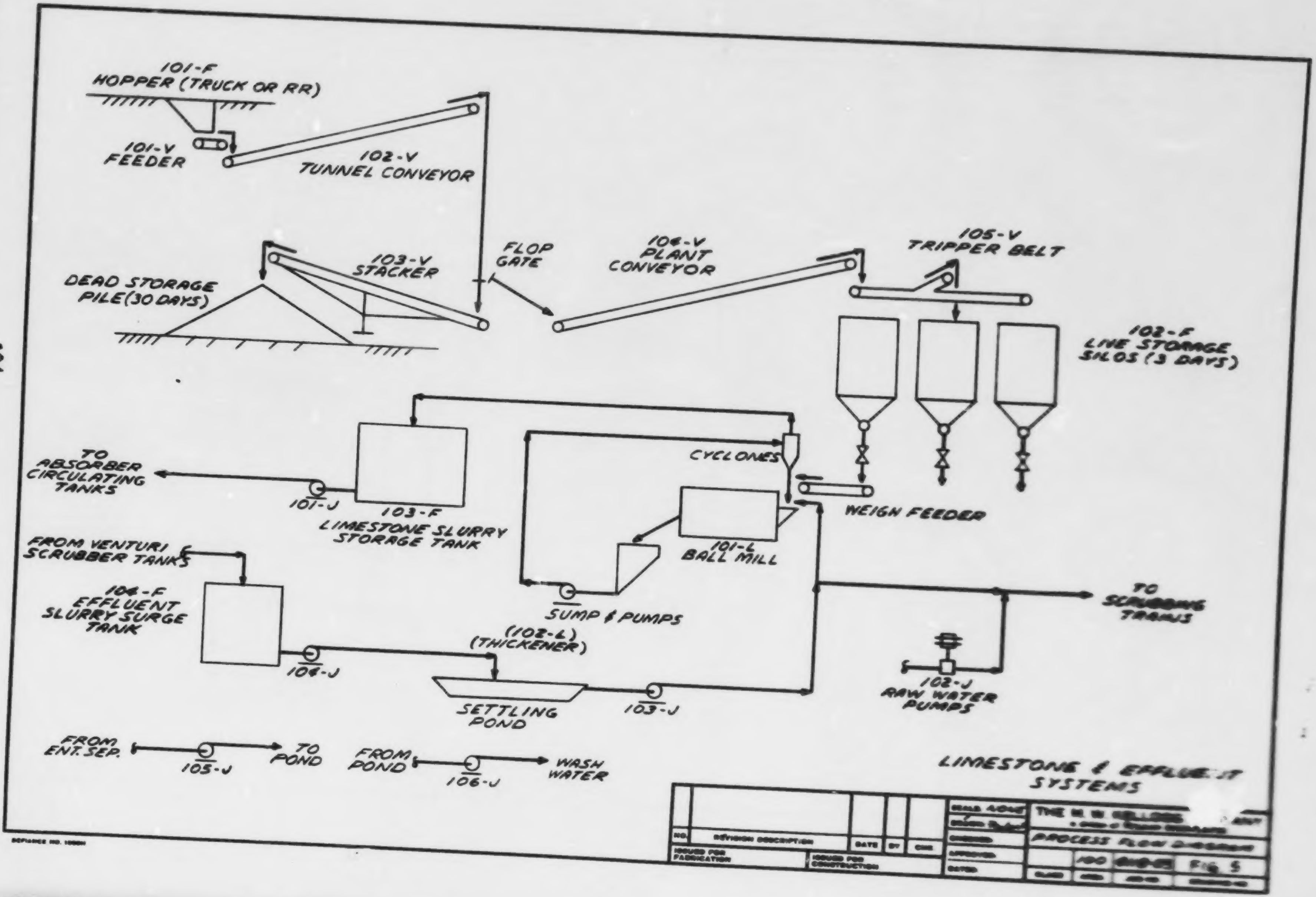
	Boiler No.1	Boiler No.2	Boiler No.3	Boiler No.	Boiler No.
Scrubbing System					
No. Scrubbing Trains Required	1	1	1		
Train Size(1)	VI	VI	IV		
Train Type					
Wet Limestone	A	A	A		
Wellman-Lord	A	A	A		
Limestone System					
Max. Design Capacity : tph	13.3				
Wellman-Lord/Allied System					
Sulfur Flow : lb./hr.	4980				
Regeneration Area : No. Trains Required	1				
Size(2)	V				
Purge/Make-up Area : No. Trains Required	1				
Size(2)	V				
SO_2 Reduction Area : No. Trains Required	1				
Size(2)	V				

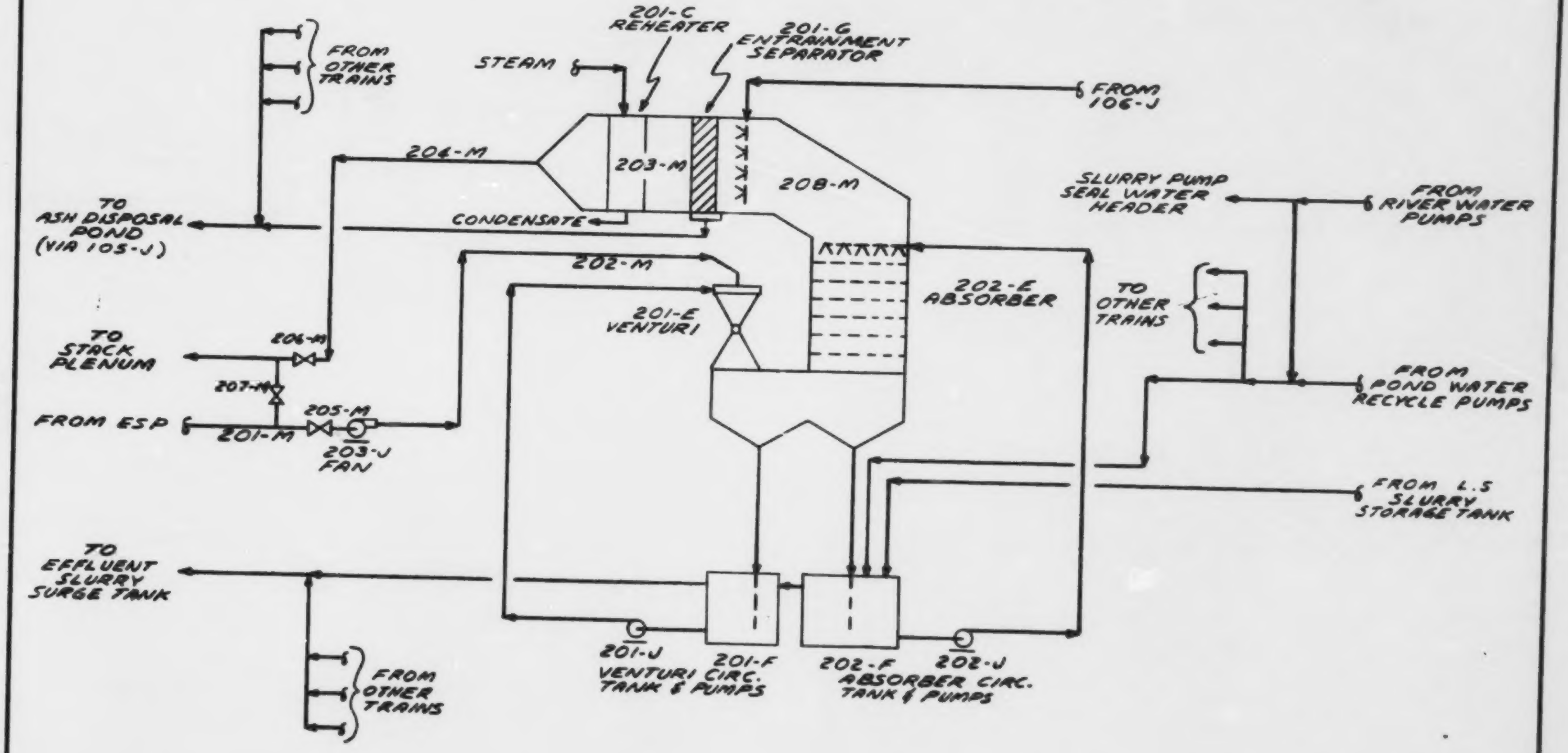
(1) Refers to standard size scrubber modules.

(2) Refers to standard size modules.

APPENDIX B

WET LIMESTONE SYSTEM


101-F
HOPPER (TRUCK OR RR)
101-V
FEEDER
102-V
TUNNEL CONVEYOR
103-V
STACKER
DEAD STORAGE
PILE (30 DAYS)
FLOP
GATE
104-V
PLANT
CONVEYOR
105-V
TRIPPER BELT
102-F
LIME STORAGE
SILOS (3 DAYS)
CYCLONES
WEIGH FEEDER
101-L
BALL MILL
SUMP & PUMPS
TO
ABSORBER
CIRCULATING
TANKS
101-J
103-F
LIMESTONE SLURRY
STORAGE TANK
FROM VENTURI
SCRUBBER TANKS
104-F
EFFLUENT
SLURRY SURGE
TANK
104-J
(102-L)
(THICKENER)
SETTLING
POND
103-J
TO
SCRUBBING
TRAINS
102-J
RAW WATER
PUMPS
FROM
ENT. SEP.
105-J
TO
POND
FROM
POND
106-J
WASH
WATER
LIMESTONE & EFFLUENT
SYSTEMS
NO.
REVISION DESCRIPTION
DATE
BY
CHK
ISSUED FOR
FABRICATION
ISSUED FOR
CONSTRUCTION
SCALE NONE
DRAWN
CHECKED
APPROVED
DATED
THE M. W. KELLOGG
PROCESS FLOW DIAGRAM
100
Fig. 5


FROM OTHER TRAINS
201-C REHEATER
201-G ENTRAINMENT SEPARATOR
STEAM
FROM 106-J
204-M
203-M
208-M
TO ASH DISPOSAL POND (VIA 105-J)
CONDENSATE
SLURRY PUMP SEAL WATER HEADER
FROM RIVER WATER PUMPS
202-M
202-E ABSORBER
201-E VENTURI
TO OTHER TRAINS
TO STACK PLENUM
206-M
207-M
205-M
FROM ESP
201-M
203-J FAN
FROM POND WATER RECYCLE PUMPS
FROM L.S SLURRY STORAGE TANK
TO EFFLUENT SLURRY SURGE TANK
FROM OTHER TRAINS
201-J
201-F VENTURI CIRC. TANK & PUMPS
202-F ABSORBER CIRC. TANK & PUMPS
202-J

SCRUBBER SYSTEM

NO.	REVISION DESCRIPTION	DATE	BY	CHK.

ISSUED FOR FABRICATION
ISSUED FOR CONSTRUCTION

SCALE: NONE
DRAWN: Tbohat
CHECKED:
APPROVED:
DATED:

THE M. W. KELLOGG COMPANY
a division of Pullman Incorporated
PROCESS FLOW DIAGRAM

CLASS	AREA	JOB NO.	DRAWING NO.
	200	2118-03	FIG. 6

REPLACES NO. 10001

7 B 11 X 17

ENG PROJ 6 9-70

Table 21
EQUIPMENT LIST

CLIENT: EPA-Iowa Utilities Study

LOCATION:

TYPE UNIT: Limestone System: Area - 100

JOB/EST. NO. 4118-03

CLASS F,J,K,L

PAGE NO.: 1 OF 4

ITEM NO.	DESCRIPTION EQUIPMENT TYPE: F-Drums and Tanks	ITEM CHANGED (✓)	ISSUE NO.
101-F	Unloading Hopper		
102-F	Live Storage Silos		
103-F	Limestone Slurry Storage Tank		
104-F	Effluent Slurry Surge Tank		
	J-Pumps and Drivers		
101-J	Limestone Slurry Feed Pumps		
102-J	Raw Water Pumps		
103-J	Pond Water Recycle Pumps		
104-J	Effluent Slurry Surge Tank Pumps		
105-J	Entrainment Separator Pumps		
106-J	Wash Water Pumps		
	K-Buildings		
101-K	Grinding Building		
	L-Special Equipment		
101-L	Ball Mills (Incl. weigh feeder, mill, classifiers, slurry sump, slurry pumps)		
102-L	Thickener (If required)		

CHECKS IN FAR RIGHT HAND COLUMN INDICATE ITEMS CHANGED IN LATEST ISSUE.

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DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.	ATTENTION OF:
DESIGN	PIPING DESIGN		CIVIL-MECH.	STANDARDS & SPECS.		PURCHASING AGENT	
	PLANT LAYOUT			CIVIL ENG.			
	MATERIAL CONTROL			FURNACE-EXCH. DIV.			
	PIPE SUPPORTS			MECHANICAL ENG. DIV.			
	PIPING INSTRUMENT		ESTIMATING SERVICES				
	LIGHT & POWER		SCHEDULING SERVICES				
	ELECTRICAL INSTRUMENT		CONST.	HOME OFFICE			
SYSTEMS	SYSTEMS ENG.			FIELD			
	INSTRUMENT ENG.		COST SERVICES				
	EQUIPMENT ENG.		PROCESS MGR.				

ISSUE NO.	1	2	3	4	5	6	7	8	9	10	11	12
DATE												

ENG PROJ 6 9-70

EQUIPMENT LIST

JOB/EST. NO. 4118-03

CLIENT: EPA - Iowa Utilities Study

LOCATION:

CLASS V

TYPE UNIT: Limestone System: Area 100

PAGE NO.: 2 OF 4

ITEM NO.	DESCRIPTION EQUIPMENT TYPE: V-Transportation Equip.	ITEM CHANGED (✓)	ISSUE NO.
101-V	Feeder		
102-V	Tunnel Belt Conveyor		
103-V	Stacker		
104-V	Plant Conveyor		
105-V	Tripper Belt		

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DESIGN	PIPING DESIGN		CIVIL-MECH.	STANDARDS & SPECS.		PURCHASING AGENT	
	PLANT LAYOUT			CIVIL ENG.			
	MATERIAL CONTROL			FURNACE - EXCH. DIV.			
	PIPE SUPPORTS			MECHANICAL ENG. DIV.			
	PIPING INSTRUMENT		ESTIMATING SERVICES				
	LIGHT & POWER		SCHEDULING SERVICES				
	ELECTRICAL INSTRUMENT		CONST.	HOME OFFICE			
SYSTEMS	SYSTEMS ENG.			FIELD			
	INSTRUMENT ENG.		COST SERVICES				
	EQUIPMENT ENG.		PROCESS MGN.				

ISSUE NO.	1	2	3	4	5	6	7	8	9	10	11	12
DATE												

ENG PROJ 6 9-70

EQUIPMENT LIST

CLIENT: EPA - Iowa Utilities Study

JOB/EST. NO. 4118-03

LOCATION:

CLASS C,E,F,G,

TYPE UNIT: Scrubbing Train: Area 200

PAGE NO.: 3 OF 4

ITEM NO.	DESCRIPTION EQUIPMENT TYPE: C-Heat Exchangers	ITEM CHANGED (✓)	ISSUE NO.
201-C	Reheater		
	E-Towers		
201-E	Venturi Scrubber		
202-E	TCA Absorber		
	F-Drums and Tanks		
201-F	Vent. Scr. Circulating Tank		
202-F	Absorber Circulating Tank		
	G-Separators		
201-G	Entrainment Separator		

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DESIGN	PIPING DESIGN		CIVIL-MECH.	STANDARDS & SPECS.		PURCHASING AGENT	
	PLANT LAYOUT			CIVIL ENG.			
	MATERIAL CONTROL			FURNACE-EXCH. DIV.			
	PIPE SUPPORTS			MECHANICAL ENG. DIV.			
	PIPING INSTRUMENT		ESTIMATING SERVICES				
	LIGHT & POWER		SCHEDULING SERVICES				
	ELECTRICAL INSTRUMENT		CONST.	HOME OFFICE			
SYSTEMS	SYSTEMS ENG.			FIELD			
	INSTRUMENT ENG.		COST SERVICES				
	EQUIPMENT ENG.		PROCESS MGR.				

ISSUE NO.	1	2	3	4	5	6	7	8	9	10	11	12
DATE												

ENG PROJ 6 9-70

EQUIPMENT LIST

JOB/EST. NO. 4118-03
CLIENT: EPA - Iowa Utilities Study
LOCATION:
CLASS J,L,M
TYPE UNIT: Scrubbing Train: Area 200
PAGE NO.: 4 OF 4

ITEM NO.	DESCRIPTION EQUIPMENT TYPE: J-Pumps, Blowers, Drivers	ITEM CHANGED (✓)	ISSUE NO.
201-J	Vent. Scr. Circulating Pumps		
202-J	Absorber Circulating Pumps		
203-J	Forced Draft Fan		
	L-Special Equipment		
201-L	Vent. Scr. Tank Agitator W/Motor		
202-L	Absorber Tank Agitator W/Motor		
203-L	Soot Blower (Inlet Duct to Venturi)		
204-L	Soot Blower (Elbow to Ent. Separator)		
205-L	Soot Blower (Reheater)		
	M-Piping		
201-M	Duct To Fan		
202-M	Duct From Fan To Vent. Scr.		
203-M	Duct From Ent. Sep. To Reheater		
204-M	Duct From Reheater To Stack Duct		
205-M	Inlet Shut-Off Gate		
206-M	Outlet Shut-Off Gate		
207-M	Bypass Shut-Off Gate		
208-M	Duct From Abs. To Ent. Separator		

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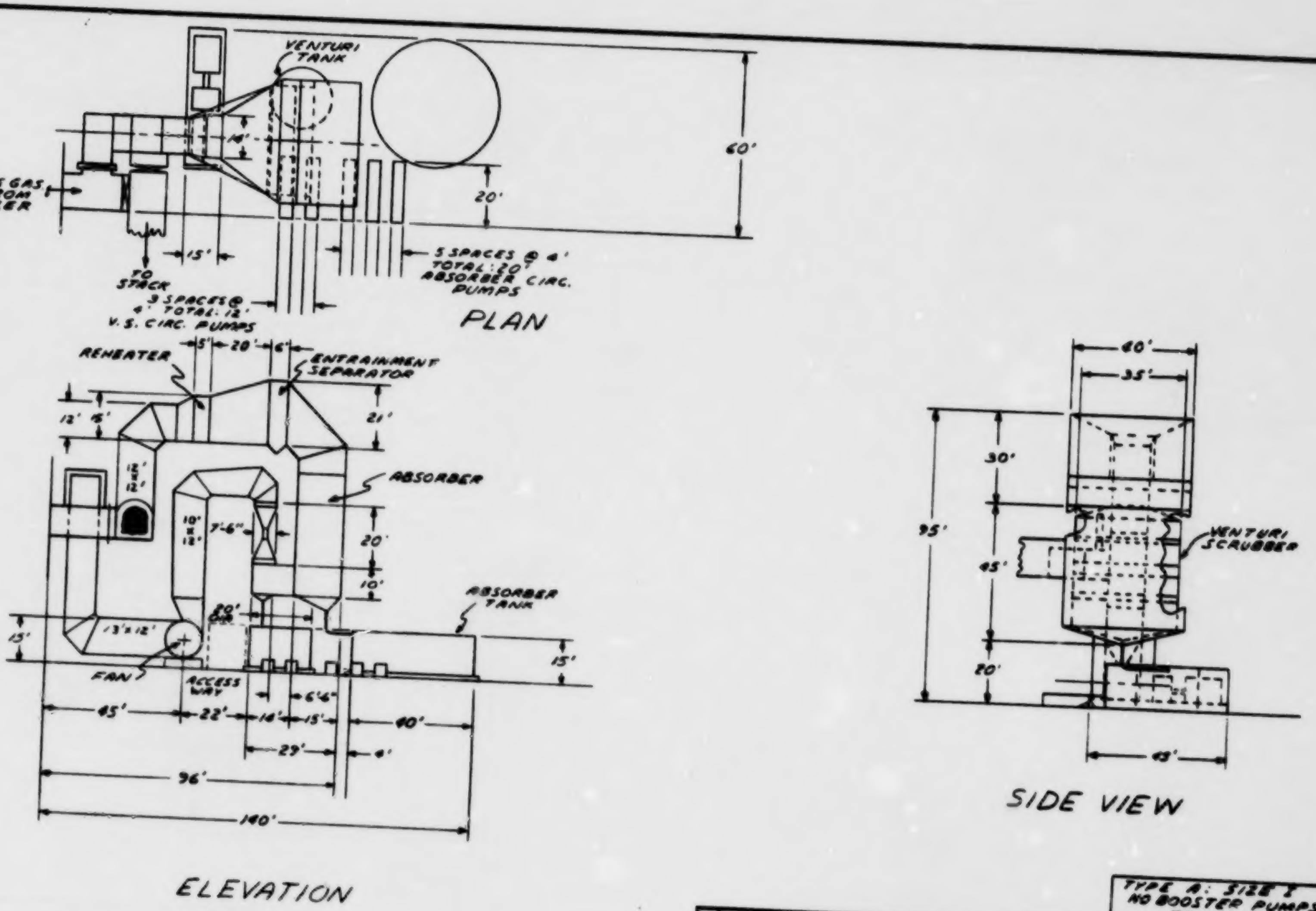
DESIGN	PIPING DESIGN		CIVIL-MECH.	STANDARDS & SPECS.		PURCHASING AGENT	
	PLANT LAYOUT			CIVIL ENG.			
	MATERIAL CONTROL			FURNACE-EXCH. DIV.			
	PIPE SUPPORTS			MECHANICAL ENG. DIV.			
	PIPING INSTRUMENT		ESTIMATING SERVICES				
	LIGHT & POWER		SCHEDULING SERVICES				
	ELECTRICAL INSTRUMENT		CONST.	HOME OFFICE			
SYSTEMS	SYSTEMS ENG.			FIELD			
	INSTRUMENT ENG.		COST SERVICES				
	EQUIPMENT ENG.		PROCESS MGR.				

ISSUE NO.	1	2	3	4	5	6	7	8	9	10	11	12
DATE												


VENTURI TANK
60'
20'
14'
FLUE GAS FROM BOILER
15'
TO STACK
3 SPACES @ 4' TOTAL: 12' V.S. CIRC. PUMPS
5 SPACES @ 4' TOTAL: 20' ABSORBER CIRC. PUMPS
PLAN
REHEATER
5'
20'
6'
ENTRAINMENT SEPARATOR
12'
15'
21'
12' x 12'
10' x 12'
7'-6"
ABSORBER
20'
10'
20' DIA
13' x 12'
ABSORBER TANK
15'
15'
FAN
ACCESS WAY
45'
22'
14'
15'
6'6"
40'
29'
4'
96'
140'
ELEVATION
40'
35'
30'
95'
45'
20'
VENTURI SCRUBBER
45'
SIDE VIEW

NO.	REVISION DESCRIPTION	DATE	BY	CHK

ISSUED FOR FABRICATION
ISSUED FOR CONSTRUCTION

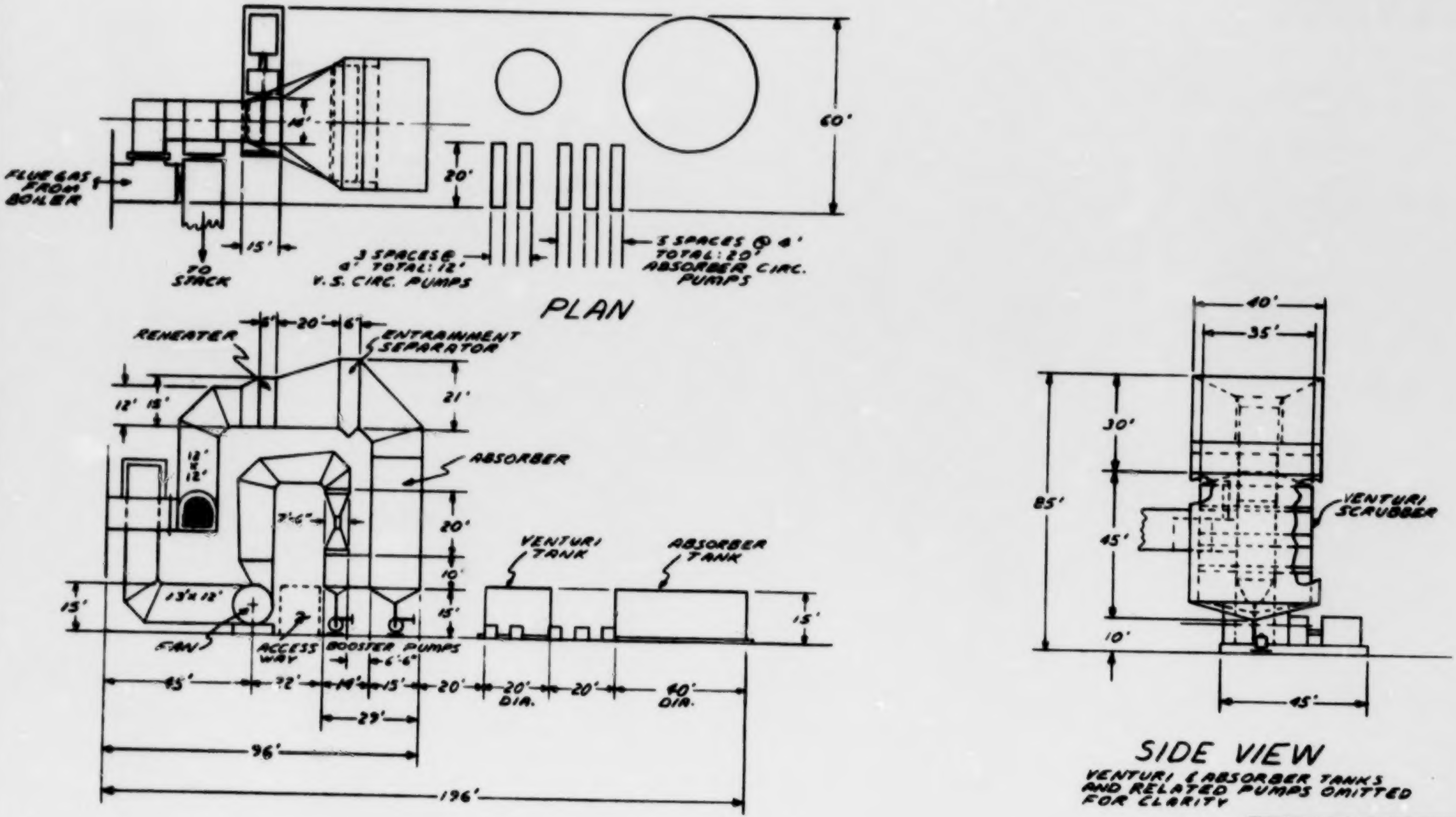
SCALE: 1" = 30'
DRAWN:
CHECKED:
APPROVED:
DATED:

TYPE A: SIZE I
NO BOOSTER PUMPS REQ'D
FAN AT GRADE

THE M. W. KELLOGG COMPANY
a division of Pullman Incorporated

STANDARD SCRUBBER MODULE

CLASS	AREA	JOB NO.	DRAWING NO.
		4118-03	FIG 7


FLUE GAS FROM BOILER
TO STACK
15'
14'
20'
60'
3 SPACES @ 4' TOTAL: 12' V.S. CIRC. PUMPS
5 SPACES @ 4' TOTAL: 20' ABSORBER CIRC. PUMPS
PLAN
REHEATER
20'
6'
ENTRAINMENT SEPARATOR
12'
15'
21'
12' x 12'
ABSORBER
7'-6"
20'
10'
15'
13' x 12'
FAN
ACCESS WAY
BOOSTER PUMPS
6'-6"
VENTURI TANK
ABSORBER TANK
15'
45'
22'
14'
15'
20'
20' DIA.
20'
40' DIA.
29'
96'
196'
ELEVATION
40'
35'
30'
85'
45'
10'
VENTURI SCRUBBER
45'
SIDE VIEW
VENTURI & ABSORBER TANKS AND RELATED PUMPS OMITTED FOR CLARITY

TYPE B: SIZE I
BOOSTER PUMPS REQ'D
FAN AT GRADE

THE M. W. KELLOGG COMPANY
a division of Pullman Incorporated

STANDARD SCRUBBER MODULE

NO.	REVISION DESCRIPTION	DATE	BY	CHK.

ISSUED FOR FABRICATION
ISSUED FOR CONSTRUCTION

SCALE: 1" = 30'
DRAWN:
CHECKED:
APPROVED:
DATED:

CLASS	AREA	JOB NO.	DRAWING NO.
		4118-03	FIG. 8

4
B
11 X 17

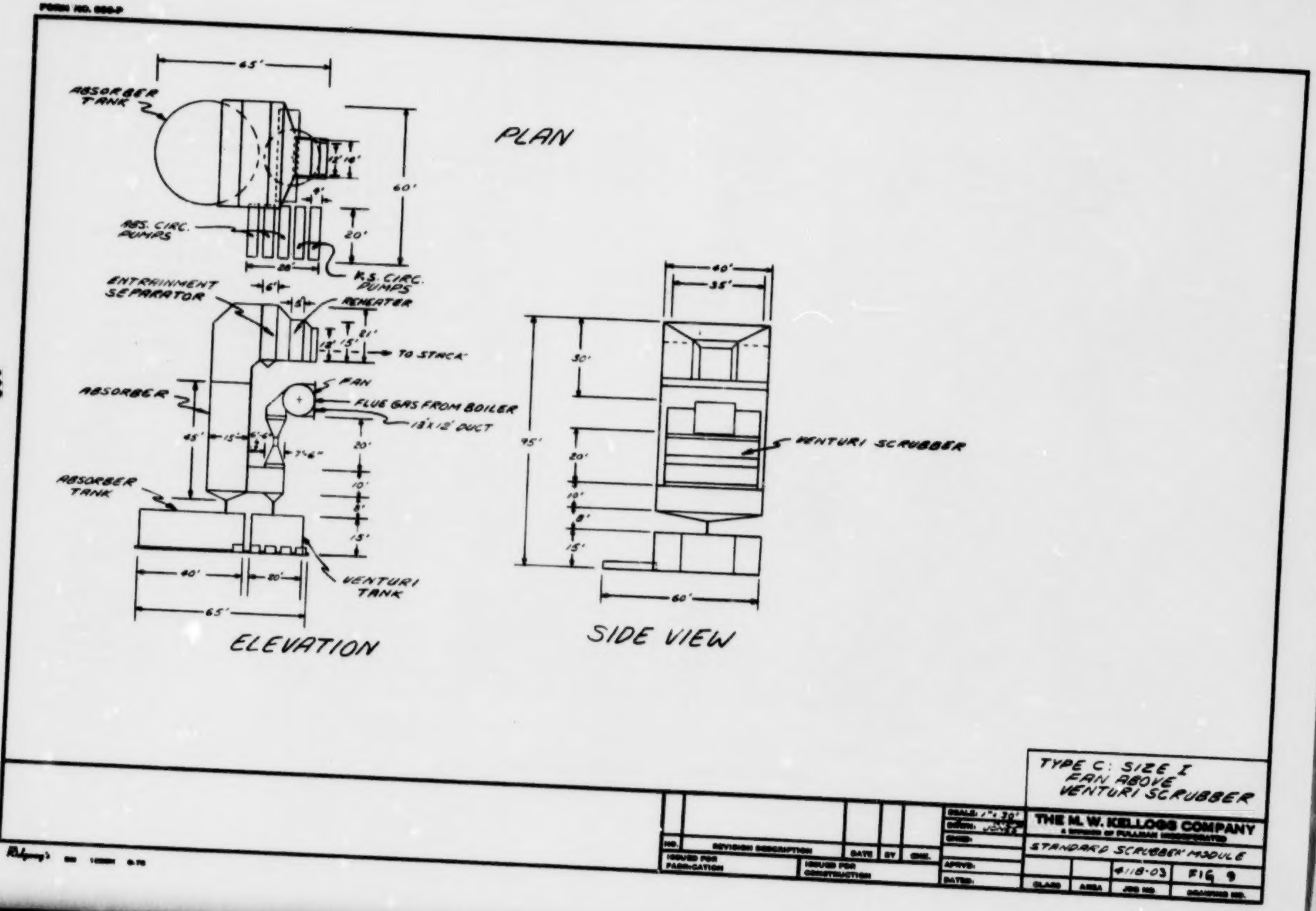
FORM NO. 660-P
PLAN
ABSORBER TANK
65'
60'
12'
16'
9'
20'
28'
ABS. CIRC. PUMPS
R.S. CIRC. PUMPS
ENTRAINMENT SEPARATOR
6'
5'
REHEATER
21'
15'
12'
TO STACK
ABSORBER
FAN
FLUE GAS FROM BOILER
13'X12' DUCT
45'
15'
5'-6"
7'-6"
20'
10'
8'
15'
ABSORBER TANK
VENTURI TANK
40'
20'
65'
ELEVATION
40'
35'
30'
95'
20'
10'
8'
15'
VENTURI SCRUBBER
60'
SIDE VIEW
TYPE C: SIZE I
FAN ABOVE
VENTURI SCRUBBER
SCALE: 1"=30'
DRWN.
CHKD.
APRVD.
DATED:
NO.
REVISION DESCRIPTION
DATE
BY
CHK.
ISSUED FOR FABRICATION
ISSUED FOR CONSTRUCTION
THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED
STANDARD SCRUBBER MODULE
CLASS
AREA
4118-03
JOB NO.
FIG 9
DRAWING NO.
B
11 X 17

Table 22
ABSORBER-VENTURI STANDARD SIZES

	I	II	III	IV	V	VI	VII	VIII
ACFM Wet @ 125°/175°	450,000/488,000	394,000/428,000	338,000/367,000	281,000/305,000	225,000/244,000	169,000/183,000	112,500/122,000	75,000/81,300
ACFM Hot @ 300°	545,000	477,000	409,000	341,000	273,000	204,000	136,000	90,900
SCFM (Hot)	373,000	326,000	280,000	233,000	187,000	140,000	93,300	62,200
Hot Duct/Stack Duct	13'x13'/13'x13'	12'x11'/11'x11'	11'x11'/10'x10'	10'x10'/10'x9'	9'x9'/9'x[illegible]	8'x8'/8'x7'	7'x6'/6'x6'	5'x5'/5'x5'
Nominal M.W.	182	159	136	114	91	68	45.5	30.3
Factor	1.000	0.875	0.750	0.625	0.500	.375	0.25	.167
ABSORBER								
L/G: GPM/MSCFM	64.5	64.5	64.5	64.5	64.5	64.5	64.5	64.5
GPM Total	24,000	21,000	18,000	15,000	12,000	9,000	6,000	4,000
Size	15' x 40'	15' x 35'	15' x 30'	15' x 25'	15' x 20'	15' x 15'	15'x10'	15'x6.67'
No. Pumps	3 (2 + SP.)	3 (2+ SP.)	3 (2 + SP.)	3 (2 + SP.)	3 (2 + SP.)	3 (2 + SP.)	3 (2 + SP.)	3 (2 + SP.)
BHP @ 65% Eff. (Tot.)	844	738	633	527	422	316	211	141
Motors: No./Hp Ea.	3/500	3/400	3/400	3/300	3/250	3/175	3/125	3/75
ABS. TANK								
Gal.	141,000	123,000	106,000	88,100	70,500	52,900	35,300	23,500
Dimen.	40' Ø x 15'	37' Ø x 15'	35' Ø x 15'	32' Ø x 15'	28' Ø x 15'	25' Ø x 15'	20' Ø x 15'	16'-4" Ø x 15'
FAN BHP @ 65% EFF.	3300	2890	2475	2060	1650	1240	825	550
VENTURI								
L/G: GPM/MSCFM	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1
GPM Total	6000	5250	4500	3750	3000	2250	1500	1000
Size								
No. Pumps	2 (1 + SP.)	2 (1 + SP.)	2 (1 + SP.)	2 (1 + SP.)	2 (1 + SP.)	2 (1 + SP.)	2 (1 + SP.)	2 (1 + SP.)
BHP @ 65% Eff. (Tot.)	231	202.5	174	145	116	87	57.8	38.5
Motors: No./Hp Ea.	2/250	2/250	2/200	2/150	2/125	2/100	2/75	2/50
VENTURI TANK								
Gal.	35,300	30,900	26,500	22,100	17,700	13,200	8830	5880
Dimen.	20' Ø x 15'	19' Ø x 15'	17' Ø x 15'	16' Ø x 15'	14' Ø x 15'	12'-4" Ø x 15'	11' Ø x 15'	8' Ø x 15'
REHEATER: q: MMBTU/H	23.9	20.9	17.9	14.9	11.9	9.0	6.0	4.9
A_o: Ft^2/Wt:Ø	14,940/60,000	13,070/52,500	11,200/45,000	9,340/37,500	7,470/30,000	5,600/22,500	3,740/15,000	2,490/10,000
Dimen: Ht/Width/Depth	15' x 14' x 45"	14' x 13' x 45"	13' x 12' x 45"	12' x 11' x 45"	11' x 10' x 45"	9' x 10' x 45"	7' x 8' x 45"	6' x 7' x 45"
No. Tubes/Dia./Length	4060/1"/14'	3850/1"/13'	3570/1"/12'	3255/1"/11'	2870/1"/10'	2130/1"/10'	1705/1"/8'	1365/1"/7'
No. Rows High/Deep	116/35	110/35	102/35	93/35	82/35	61/35	51/35	39/35

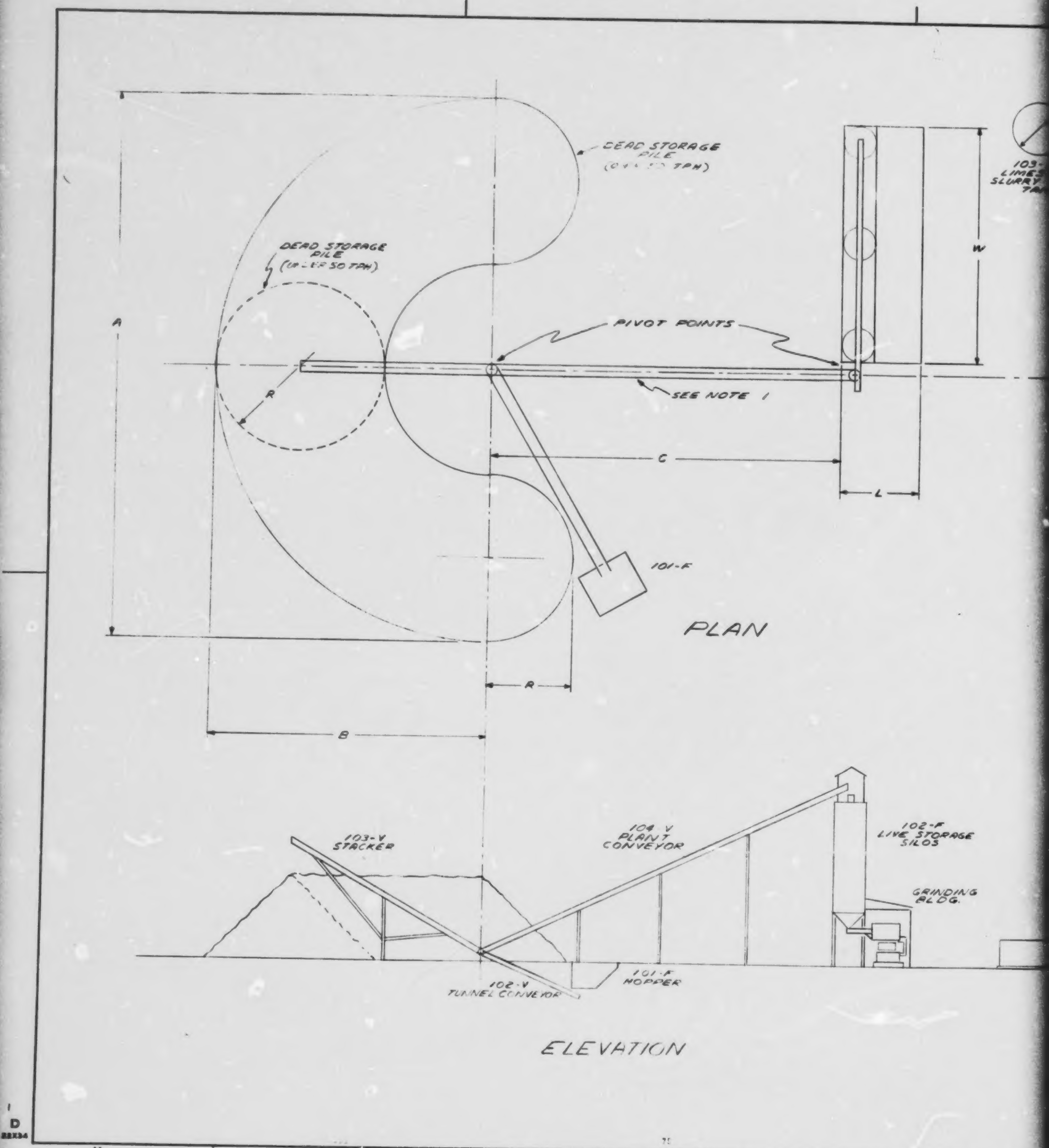
Table 23
WET LIMESTONE PROCESS

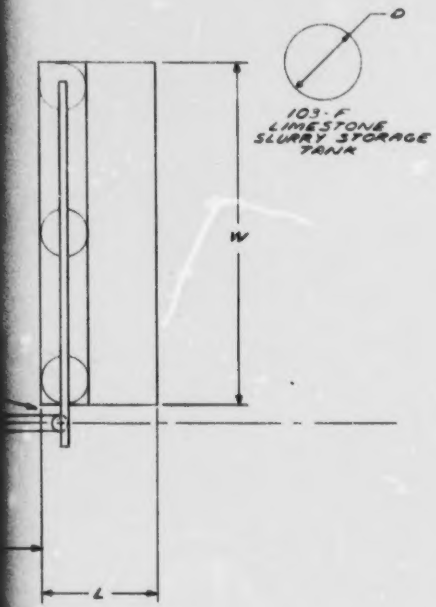
STANDARD SIZES

Scrubber Area Dimensions: Ft. (Width x Length)

SIZE	I	II	III	IV	V	VI	VII	VIII
Type A	60 x 140	56 x 136	52 x 132	48 x 128	44 x 124	40 x 120	36 x 116	32 x 112
Type B	60 x 196	56 x 190	52 x 184	48 x 178	44 x 172	40 x 165	36 x 159	32 x 153
Type C	60 x 65	56 x 61	52 x 57	48 x 53	44 x 49	40 x 45	36 x 41	32 x 37

Notes: Type A has fan at grade (HT = 95')
Type B has fan at grade with additional pumps (HT = 85')
Type C has fan over venturi scrubber (HT = 95')


DEAD STORAGE PILE (OVER 50 TPH)
DEAD STORAGE PILE (UNDER 50 TPH)
PIVOT POINTS
SEE NOTE 1
A
B
C
R
R
W
L
101-F
103-
LIMES
SLURRY
TA
PLAN
103-V STACKER
104-V PLANT CONVEYOR
102-F LIVE STORAGE SILOS
GRINDING BLDG.
102-V TUNNEL CONVEYOR
101-F HOPPER
ELEVATION
H
G
F
E
D
1
D
22X34


D
103-F
LIMESTONE
SLURRY STORAGE
TANK
W
L

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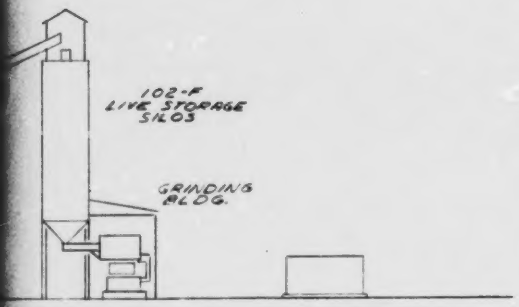

102-F
LIVE STORAGE
SILOS
GRINDING
BLDG.

0
25
50
100
FEET

NOTE:

1. COMPONENTS OF SYSTEM CAN BE ROTATED ABOUT PIVOT POINTS TO SUIT SITE, AND CONVEYOR (DIM. C) CAN BE LENGTHENED OR BROKEN INTO SMALLER UNITS TO BEND AROUND OBSTRUCTIONS.

THE M. W. KELLOGG COMPANY

LIMESTONE HANDLING & GRINDING

		4118-03	FIG. 10
CLASS	AREA	JOB NO.	DRAWING NO.

Table 24

SLURRY POND

150 CY/H FOR A 550 MW PLANT BURNING 4.3% SULFUR COAL
150% STOIC. QUANTITY; SLUDGE IS 40% SOLIDS
70% LOAD FACTOR (6132 HR/YR)

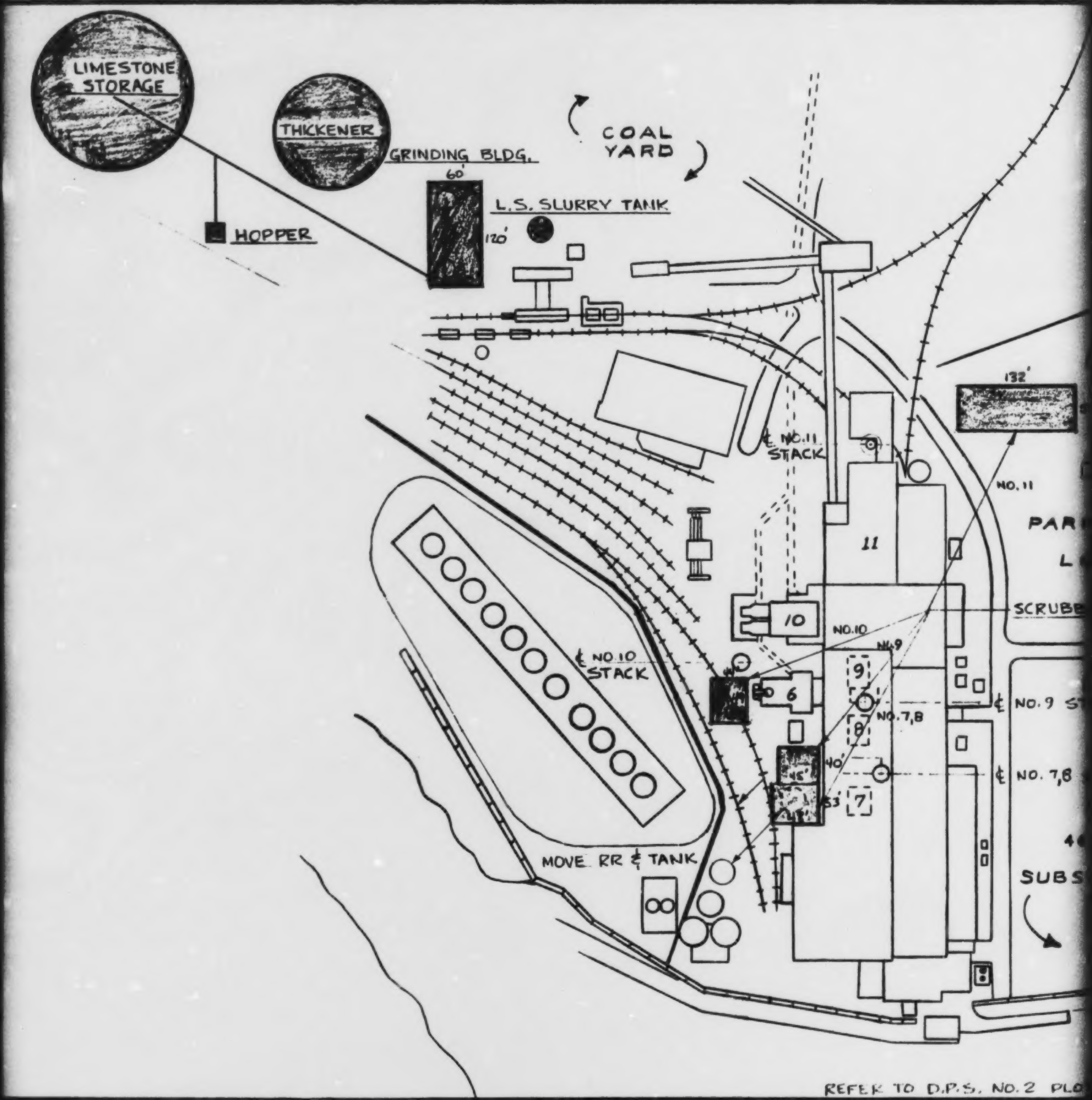
	NUMBER YEARS STORAGE				
PLANT SIZE: MW	5 YRS	10 YRS	15 YRS	20 YRS	25 YRS
200	1.67 MMCY (20.7)	3.3 MMCY (41.5)	5.02 MMCY (62.2)	6.69 MMCY (82.9)	8.36 MMCY (103.6)
400	3.34 MMCY (41.4)	6.70 MMCY (83.1)	10.04 MMCY (124.5)	13.38 MMCY (165.9)	16.72 MMCY (207.3)
600	5.01 MMCY (62.1)	10.05 MMCY (124.6)	15.06 MMCY (186.7)	20.07 MMCY (248.8)	25.08 MMCY (310.9)
800	6.68 MMCY (82.8)	13.40 MMCY (166.1)	20.08 MMCY (248.9)	26.76 MMCY (331.7)	33.44 MMCY (414.5)
1000	8.35 MMCY (103.5)	16.75 MMCY (207.6)	25.10 MMCY (311.2)	33.45 MMCY (414.7)	41.80 MMCY (518.2)

Sample Calculation: Calculate the pond size (50 feet deep) required for a 1180 MW power plant burning 3.2% sulfur coal with a load factor of 60% to hold 20 yrs. stg.

$$\text{Area} = \text{Area}_{1000}\ \underset{\text{Ratio}}{(\text{Gen. Cap.})}\ \underset{\text{Ratio}}{(\text{Fraction Sulfur})}\ \underset{\text{Ratio}}{(\text{Load Factor})}$$

$$\text{Area} = 414.7 \times \frac{1180}{1000} \times \frac{.032}{.043} \times \frac{.600}{.700} = 312 \text{ Acres}$$

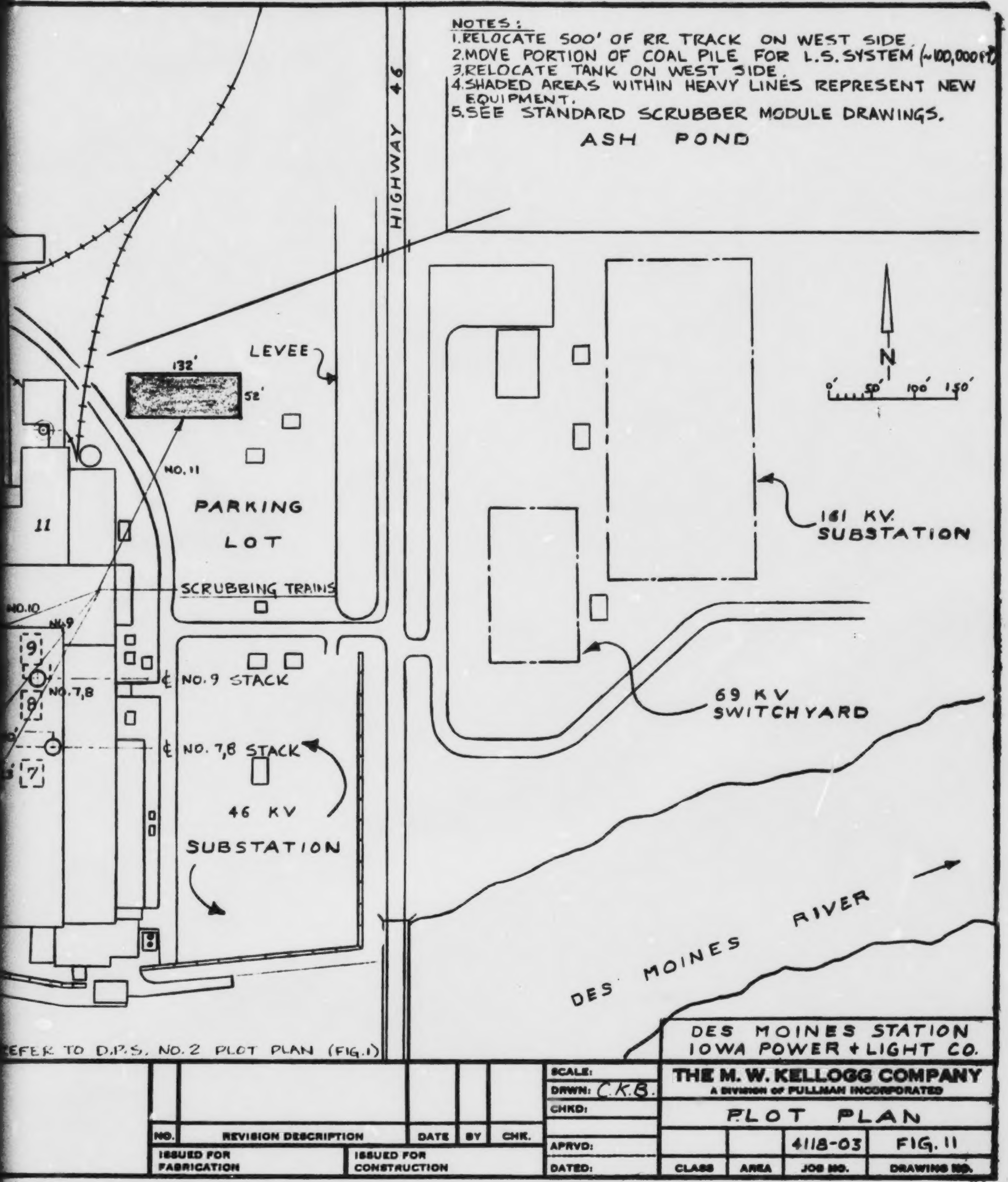
No. in parentheses ( ) = No. of acres of pond 50' deep


LIMESTONE STORAGE
THICKENER
GRINDING BLDG.
60'
120'
L.S. SLURRY TANK
HOPPER
COAL YARD
℄ NO.11 STACK
132'
NO.11
PAR
L
11
10
SCRUBB
NO.10
NO.9
9
8
7
6
℄ NO.10 STACK
NO.7,8
℄ NO.9 ST
℄ NO. 7,8
40
45'
53'
46
MOVE RR & TANK
SUBS

REFER TO D.P.S. NO.2 PLO

NO.	REV

ISSUED FOR FABRICATION


ASH POND
HIGHWAY 46
LEVEE
132'
52'
NO. 11
PARKING
LOT
11
SCRUBBING TRAINS
NO. 10
NO. 9
NO. 7,8
9
8
7
℄ NO. 9 STACK
℄ NO. 7,8 STACK
46 KV
SUBSTATION
161 KV.
SUBSTATION
69 KV
SWITCHYARD
N
0' 50' 100' 150'
DES MOINES RIVER
EFER TO D.P.S. NO. 2 PLOT PLAN (FIG. 1)

NOTES:
1. RELOCATE 500' OF RR TRACK ON WEST SIDE.
2. MOVE PORTION OF COAL PILE FOR L.S. SYSTEM (~100,000 ft)
3. RELOCATE TANK ON WEST SIDE.
4. SHADED AREAS WITHIN HEAVY LINES REPRESENT NEW EQUIPMENT.
5. SEE STANDARD SCRUBBER MODULE DRAWINGS.

DES MOINES STATION
IOWA POWER + LIGHT CO.

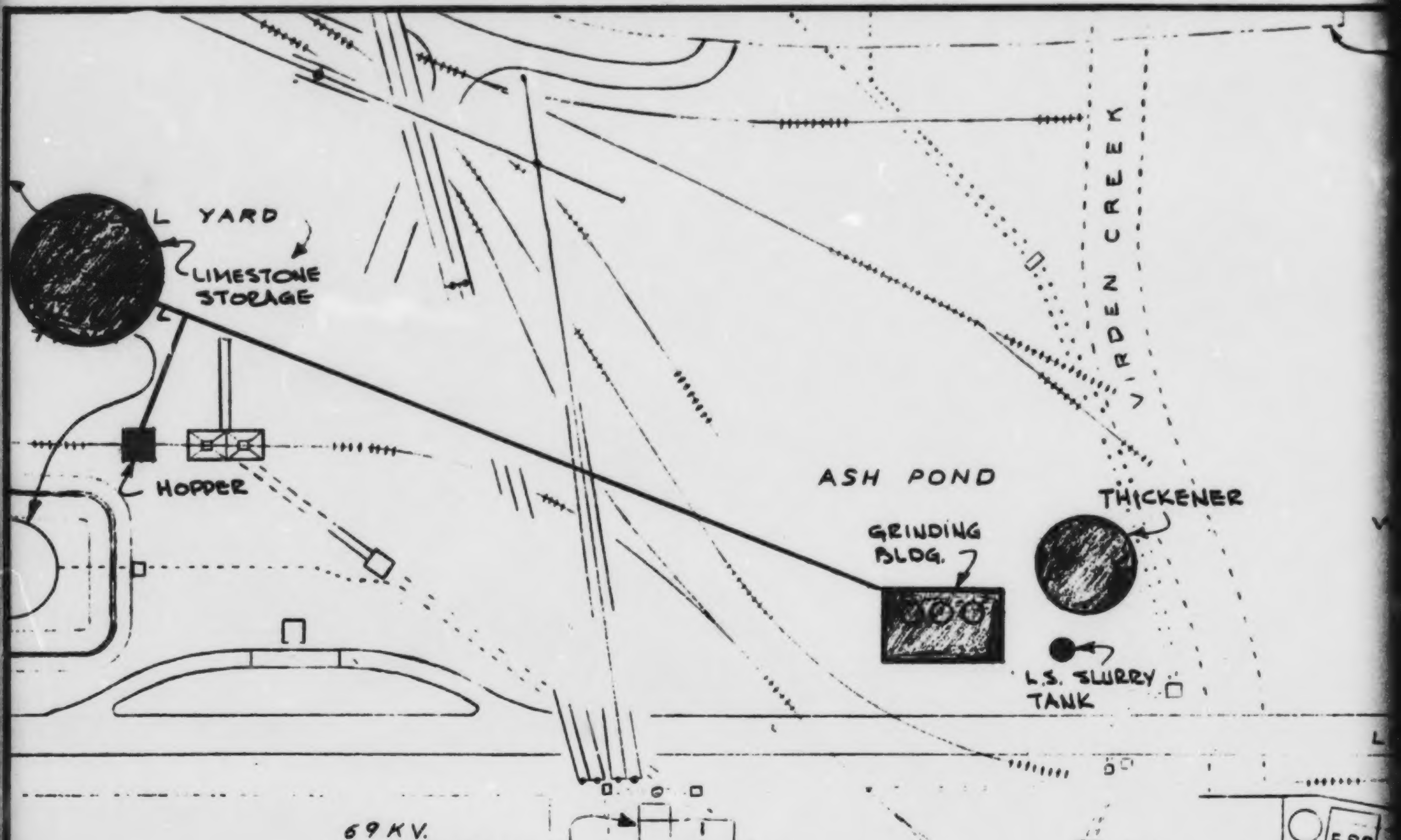
THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED

PLOT PLAN

NO.	REVISION DESCRIPTION	DATE	BY	CHK.
ISSUED FOR FABRICATION	ISSUED FOR CONSTRUCTION			

SCALE:
DRWN: C.K.B.
CHKD:
APRVD:
DATED:

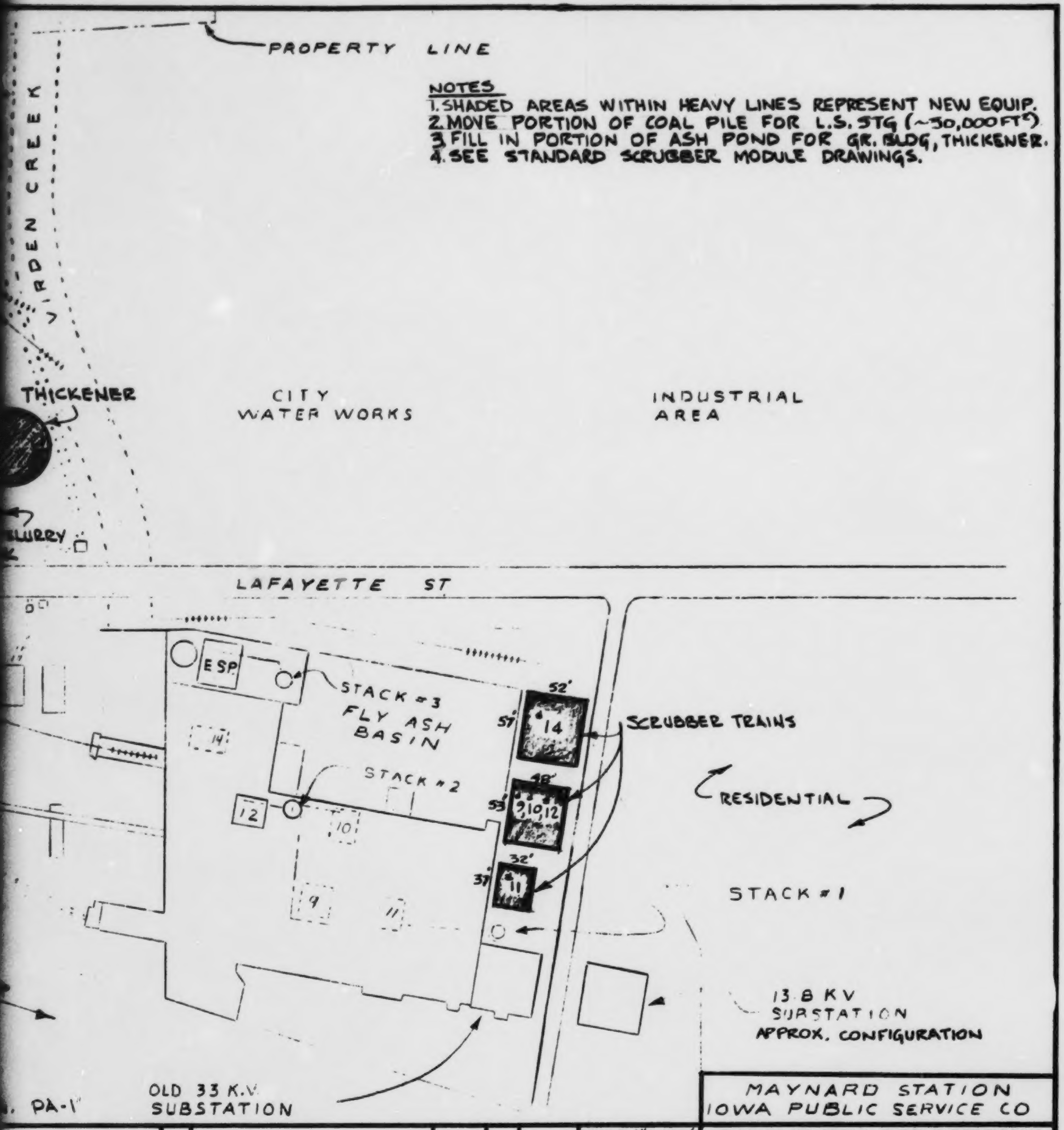
CLASS	AREA	JOB NO.	DRAWING NO.
		4118-03	FIG. 11


L YARD
LIMESTONE
STORAGE
HOPPER
ASH POND
GRINDING
BLDG.
THICKENER
L.S. SLURRY
TANK
VIRDEN CREEK
69 KV.
SUBSTATION
E SP.
14
11
34.5 KV
SUBSTATION
N
CEDAR RIVER
GRAPHIC SCALE
50
0
50
100
OLD 33 K.V
SUBSTAT

REFER TO MAYNARD STATION PLOT PLAN DWG. PA-1

NO.

ISSUED FOR
FABRICATIO


PROPERTY LINE
VIRDEN CREEK
THICKENER
SLURRY
CITY WATER WORKS
INDUSTRIAL AREA
LAFAYETTE ST
ESP
STACK #3
FLY ASH BASIN
14
STACK #2
12
10
9
11
52'
57'
14
48'
53'
9,10,12
32'
37'
11
SCRUBBER TRAINS
RESIDENTIAL
STACK #1
13.8 KV SUBSTATION
APPROX. CONFIGURATION
OLD 33 K.V. SUBSTATION
PA-1"

NOTES
1. SHADED AREAS WITHIN HEAVY LINES REPRESENT NEW EQUIP.
2. MOVE PORTION OF COAL PILE FOR L.S. STG (~30,000 FT²)
3. FILL IN PORTION OF ASH POND FOR GR. BLDG, THICKENER.
4. SEE STANDARD SCRUBBER MODULE DRAWINGS.

MAYNARD STATION
IOWA PUBLIC SERVICE CO

THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED

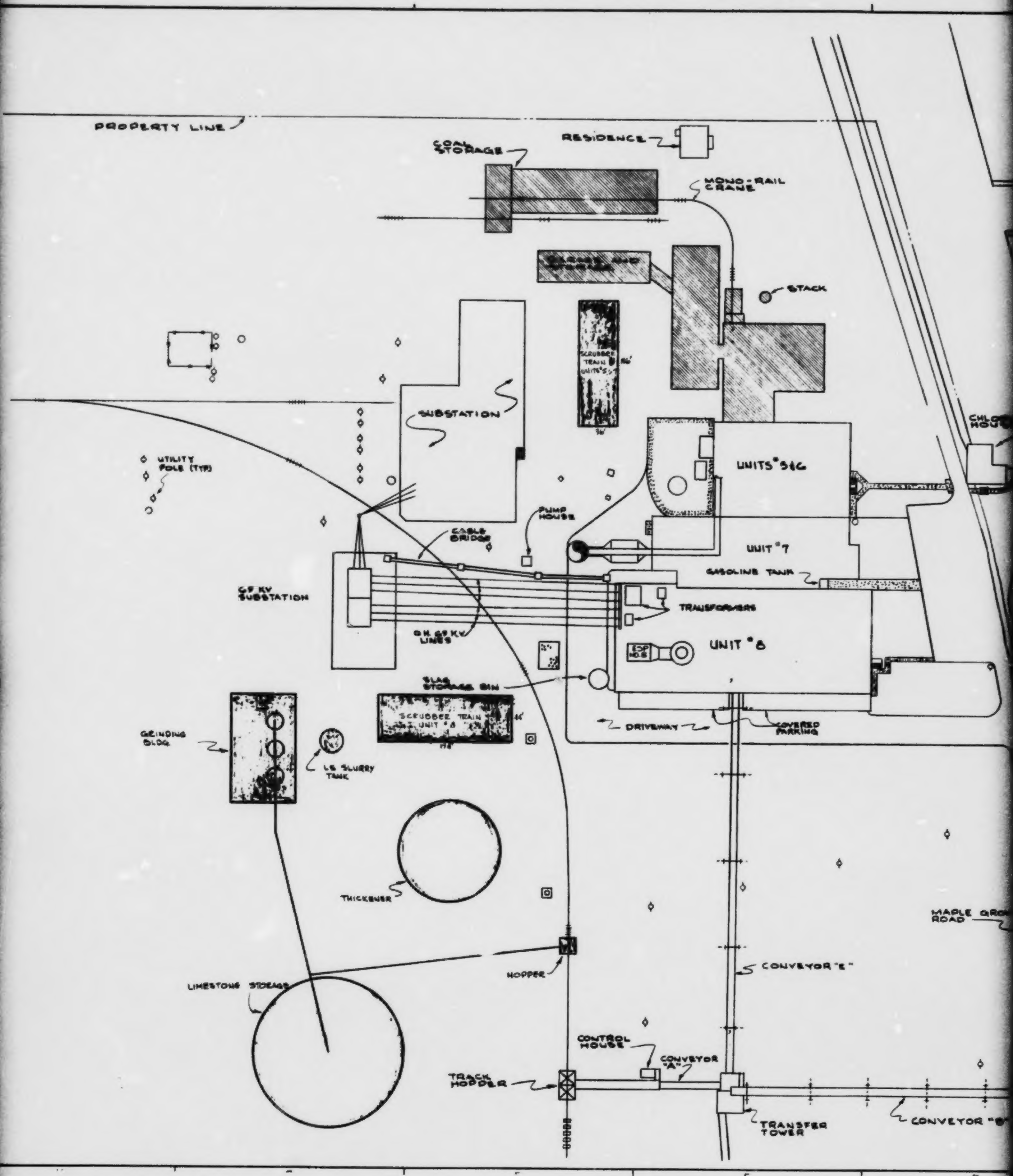
PLOT PLAN

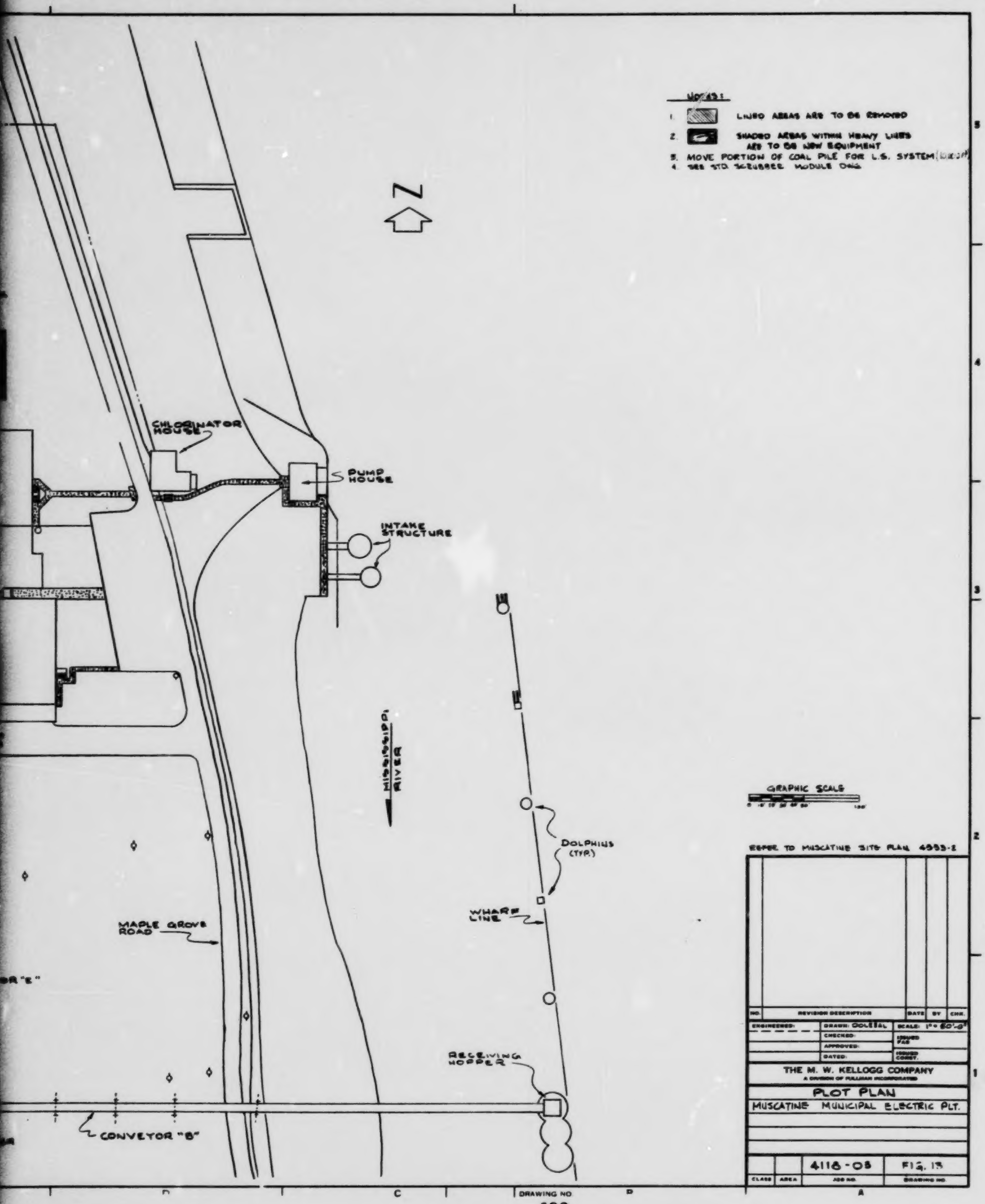
NO.	REVISION DESCRIPTION	DATE	BY	CHK.

ISSUED FOR FABRICATION
ISSUED FOR CONSTRUCTION

SCALE: 1" = 100'
DRWN: CKB
CHKD:
APRVD:
DATED:

CLASS	AREA	JOB NO.	DRAWING NO.
		4118-03	FIG. 12


PROPERTY LINE
RESIDENCE
COAL STORAGE
MONO-RAIL CRANE
STACK
SCRUBBER TRAIN UNITS 5
SUBSTATION
UTILITY POLE (TYP)
UNITS 5&6
UNIT 7
PUMP HOUSE
CABLE BRIDGE
69 KV SUBSTATION
GASOLINE TANK
TRANSFORMERS
O.H. 69 KV LINES
ESP NO. 8
UNIT 8
SLAG STORAGE BIN
SCRUBBER TRAIN UNIT 8
GRINDING BLDG.
LS SLURRY TANK
DRIVEWAY
COVERED PARKING
THICKENER
MAPLE GRO
ROAD
CHLO
HOUS
HOPPER
CONVEYOR "E"
LIMESTONE STORAGE
CONTROL HOUSE
CONVEYOR "A"
TRACK HOPPER
TRANSFER TOWER
CONVEYOR "B"


N
CHLORINATOR HOUSE
PUMP HOUSE
INTAKE STRUCTURE
MISSISSIPPI RIVER
GRAPHIC SCALE
0 10 20 30 40 50 100
DOLPHINS (TYP.)
WHARF LINE
MAPLE GROVE ROAD
RECEIVING HOPPER
CONVEYOR "B"
OR "E"
D
C
B
A
5
4
3
2
1
DRAWING NO.

NOTES:

1. ▨ LINED AREAS ARE TO BE REMOVED
2. ■ SHADED AREAS WITHIN HEAVY LINES ARE TO BE NEW EQUIPMENT
3. MOVE PORTION OF COAL PILE FOR L.S. SYSTEM (12.2.77)
4. SEE STD. SCRUBBER MODULE DWG.

REFER TO MUSCATINE SITE PLAN 4933-1

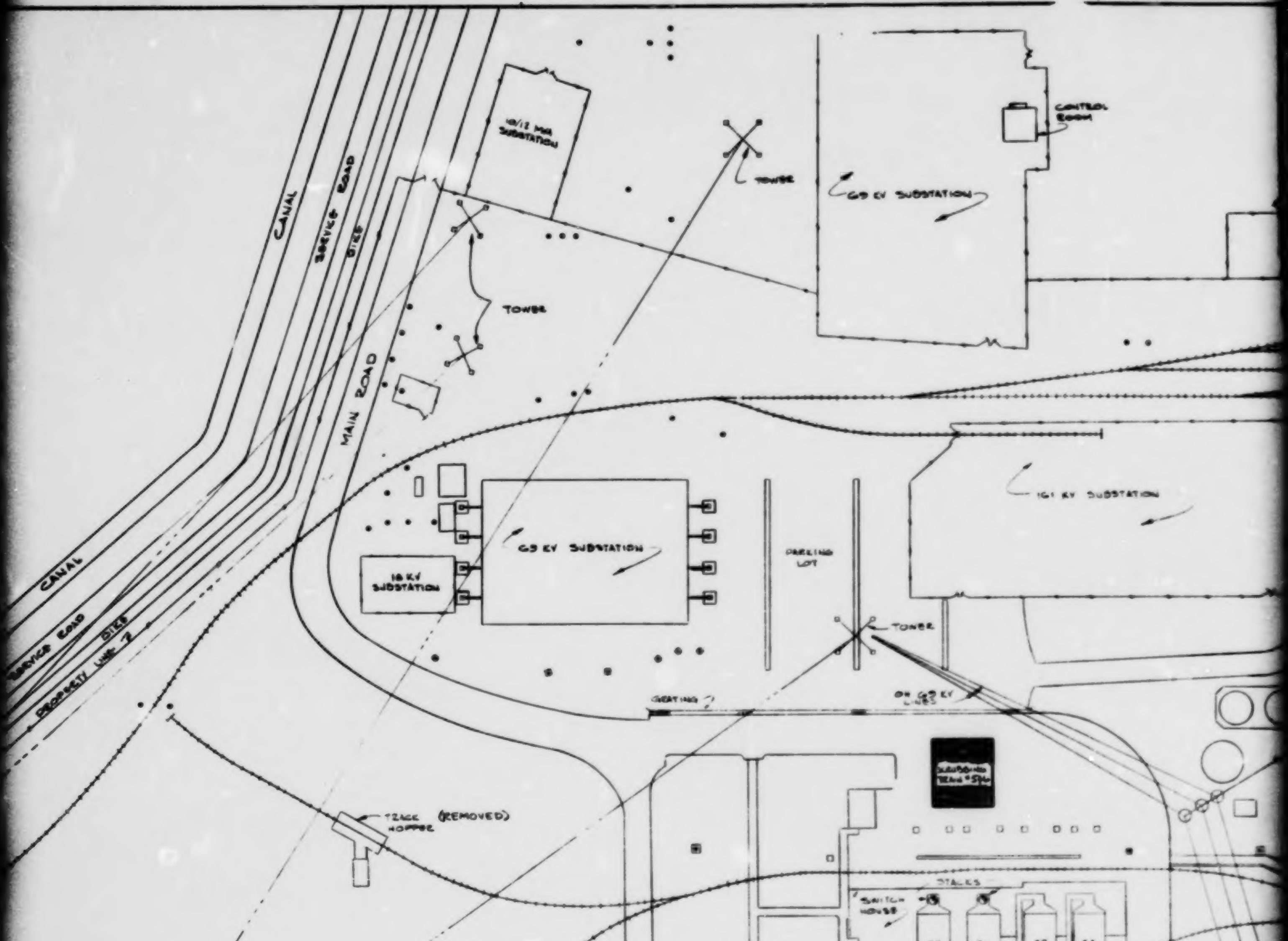
NO.	REVISION DESCRIPTION	DATE	BY	CHK.

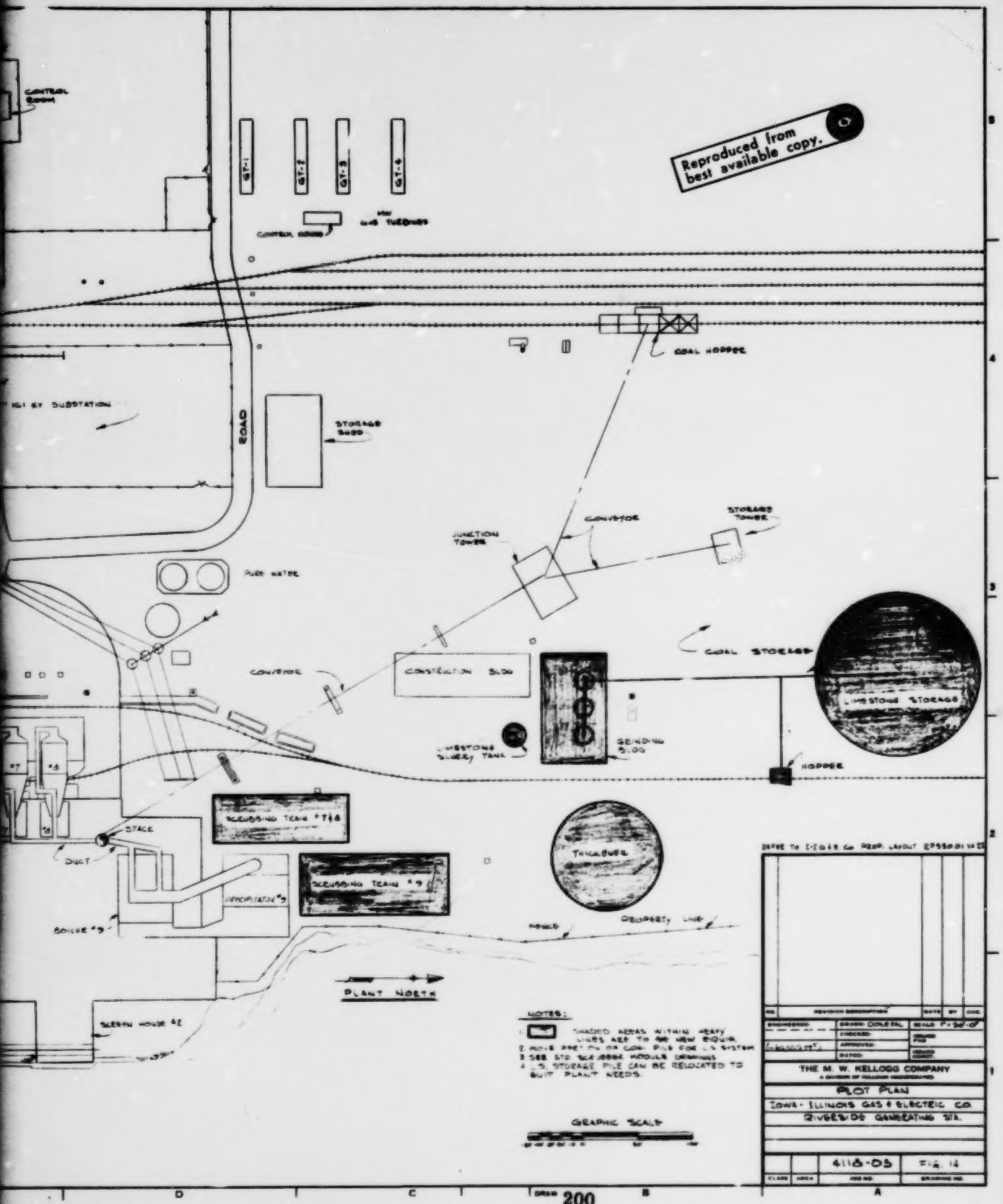
ENGINEERED:	DRAWN: DOLETAL	SCALE: 1" = 50'-0"
	CHECKED:	ISSUED FAB.
	APPROVED:	
	DATED:	ISSUED CONST.

THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED

PLOT PLAN
MUSCATINE MUNICIPAL ELECTRIC PLT.

CLASS	AREA	JOB NO.	DRAWING NO.
		4118-03	FIG. 13


CANAL
SERVICE ROAD
DIKE
MAIN ROAD
CANAL
SERVICE ROAD
DIKE
PROPERTY LINE ?
10/12 MVA SUBSTATION
TOWER
TOWER
69 KV SUBSTATION
CONTROL ROOM
161 KV SUBSTATION
69 KV SUBSTATION
13 KV SUBSTATION
PARKING LOT
TOWER
GRATING ?
OH 69 KV LINES
SCRUBBING TRAIN #5/6
TRACK HOPPER (REMOVED)
STACKS
SWITCH HOUSE
#5
#6
#7
#8
PRECIPITATORS
#5
#6
#7
#8
BOILERS
STACK
DUCT
BREAKER HOUSE (REMOVED)
MAIN BUILDING
BOILER #9
STOCK ROOM
PROPERTY LINE
RIVER CROSSING TOWER
SCREEN HOUSE #1
SCREEN HOUSE #2
MISSISSIPPI RIVER
FLOW
H
G
F
E
D


CONTROL ROOM
GT-1
GT-2
GT-3
GT-4
GAS TURBINES
CONTROL HOUSE
COAL HOPPER
161 KV SUBSTATION
ROAD
STORAGE SHED
JUNCTION TOWER
CONVEYOR
STORAGE TOWER
PURE WATER
COAL STORAGE
CONVEYOR
CONSTRUCTION BLDG
LIMESTONE STORAGE
LIMESTONE SLURRY TANK
GRINDING BLDG
HOPPER
#7
#8
STACK
DUCT
SCRUBBING TRAIN #7 & 8
SCRUBBING TRAIN #9
PRECIPITATOR #9
BOILER #9
THICKENER
FENCE
PROPERTY LINE
PLANT NORTH
SCREEN HOUSE #2
REFER TO I-I G & E Co. PROP. LAYOUT
NOTES:
1. SHADED AREAS WITHIN HEAVY LINES ARE TO BE NEW EQUIP.
2. MOVE PORTION OF COAL PILE FOR L.S. SYSTEM
3. SEE STD SCRUBBER MODULE DRAWINGS
4. L.S. STORAGE PILE CAN BE RELOCATED TO SUIT PLANT NEEDS.
GRAPHIC SCALE
NO.
REVISION DESCRIPTION
DATE
BY
CHK.
ENGINEERED
DRAWN
CHECKED
APPROVED
DATED
SCALE
THE M. W. KELLOGG COMPANY
PLOT PLAN
IOWA - ILLINOIS GAS & ELECTRIC CO.
RIVERSIDE GENERATING STA.
4118-03
FIG. 14
CLASS
AREA
JOB NO.
DRAWING NO.
A
B
C
D
1
2
3
4
5

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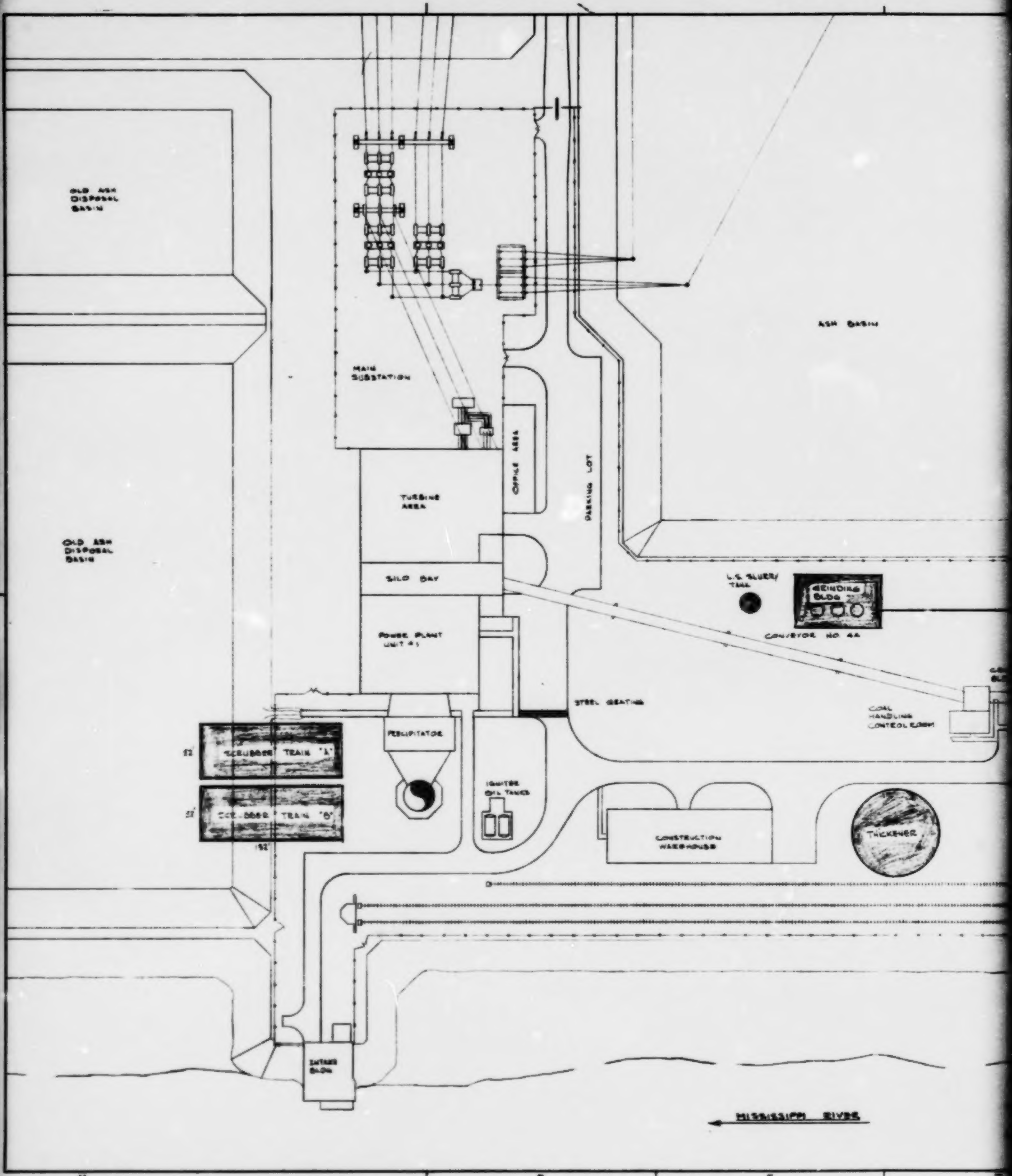
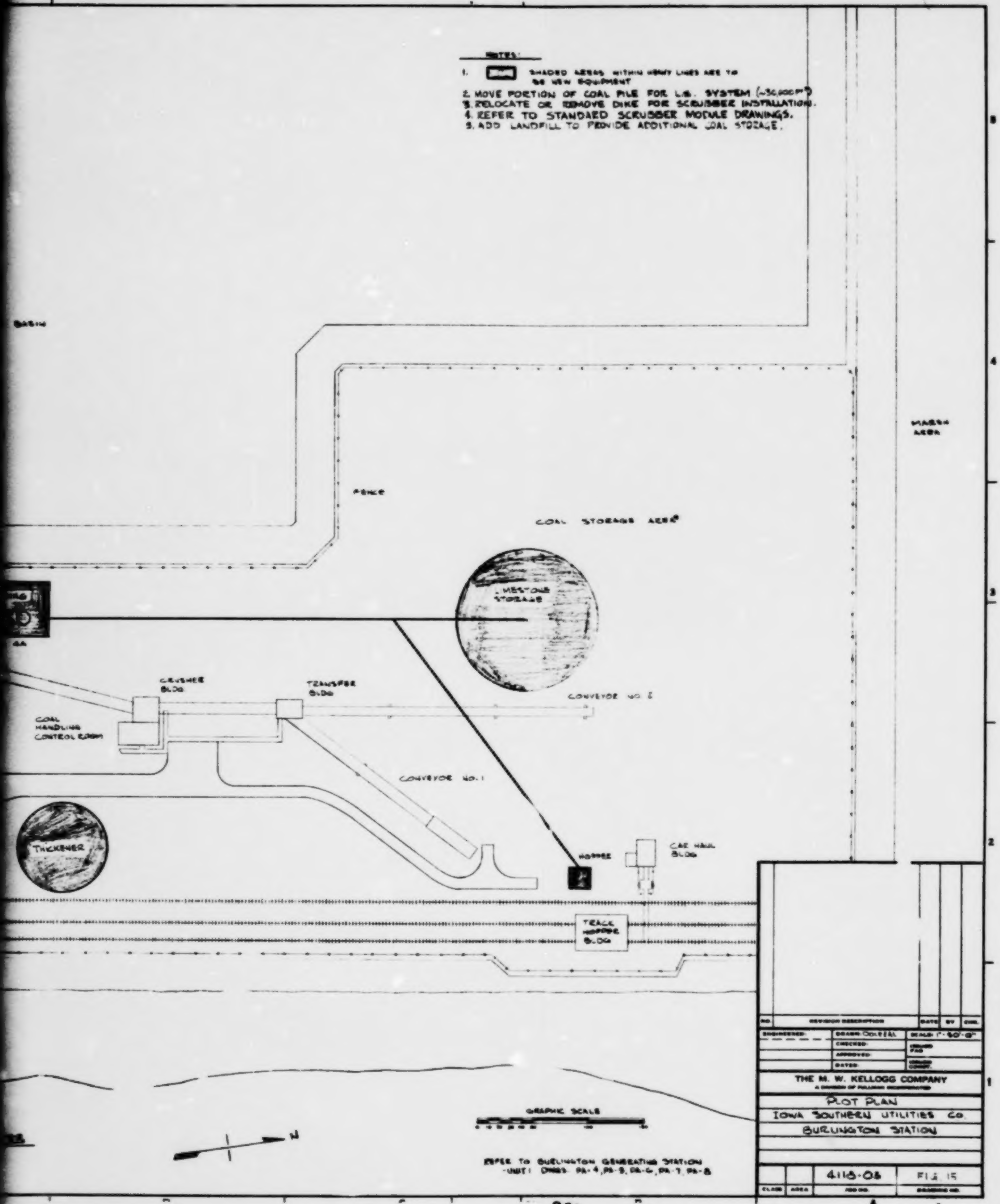

OLD ASH DISPOSAL BASIN
OLD ASH DISPOSAL BASIN
MAIN SUBSTATION
ASH BASIN
OFFICE AREA
PARKING LOT
TURBINE AREA
SILO BAY
POWER PLANT UNIT #1
L.S. SLURRY TANK
GRINDING BLDG
CONVEYOR NO 4A
STEEL GRATING
COAL HANDLING CONTROL ROOM
PRECIPITATOR
52'
SCRUBBER TRAIN "A"
52'
SCRUBBER TRAIN "B"
152'
IGNITER OIL TANKS
CONSTRUCTION WAREHOUSE
THICKENER
INTAKE BLDG
MISSISSIPPI RIVER
H


BASIN
FENCE
COAL STORAGE AREA⁵
LIMESTONE STORAGE
MARSH AREA
CRUSHER BLDG
TRANSFER BLDG
CONVEYOR NO. 2
COAL HANDLING CONTROL ROOM
CONVEYOR NO. 1
THICKENER
HOPPER
CAR HAUL BLDG
TRACK HOPPER BLDG
GRAPHIC SCALE
N

NOTES:

1. ▨ SHADED AREAS WITHIN HEAVY LINES ARE TO BE NEW EQUIPMENT
2. MOVE PORTION OF COAL PILE FOR L.S. SYSTEM (~30,000 FT²)
3. RELOCATE OR REMOVE DIKE FOR SCRUBBER INSTALLATION.
4. REFER TO STANDARD SCRUBBER MODULE DRAWINGS.
5. ADD LANDFILL TO PROVIDE ADDITIONAL COAL STORAGE.

REFER TO BURLINGTON GENERATING STATION
UNIT 1 DWGS. PA-4, PA-5, PA-6, PA-7, PA-8

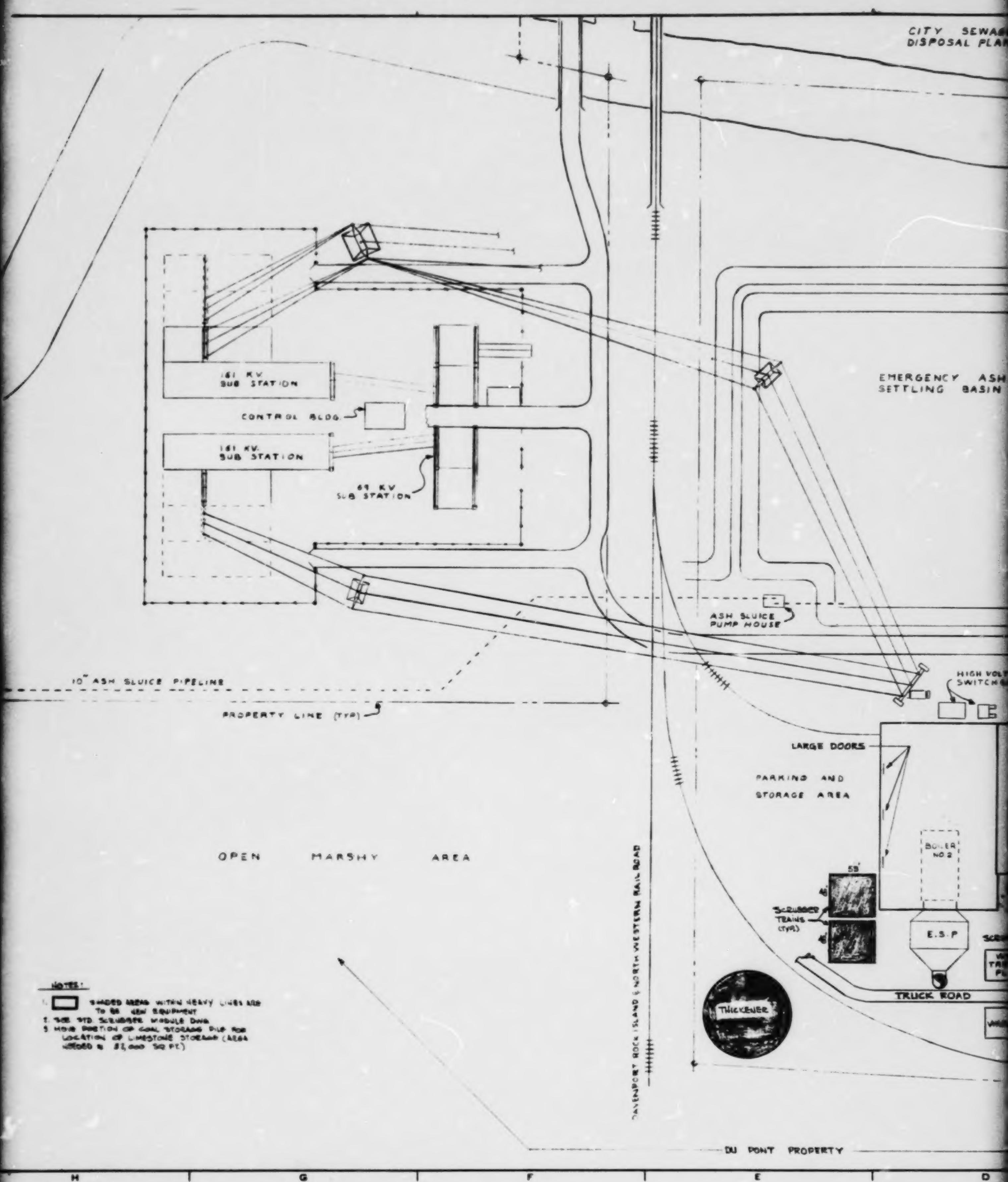
NO.	REVISION DESCRIPTION	DATE	BY	CHK.

ENGINEERED:
DRAWN: COLLEAL
CHECKED:
APPROVED:
DATED:
SCALE: 1" = 50'-0"

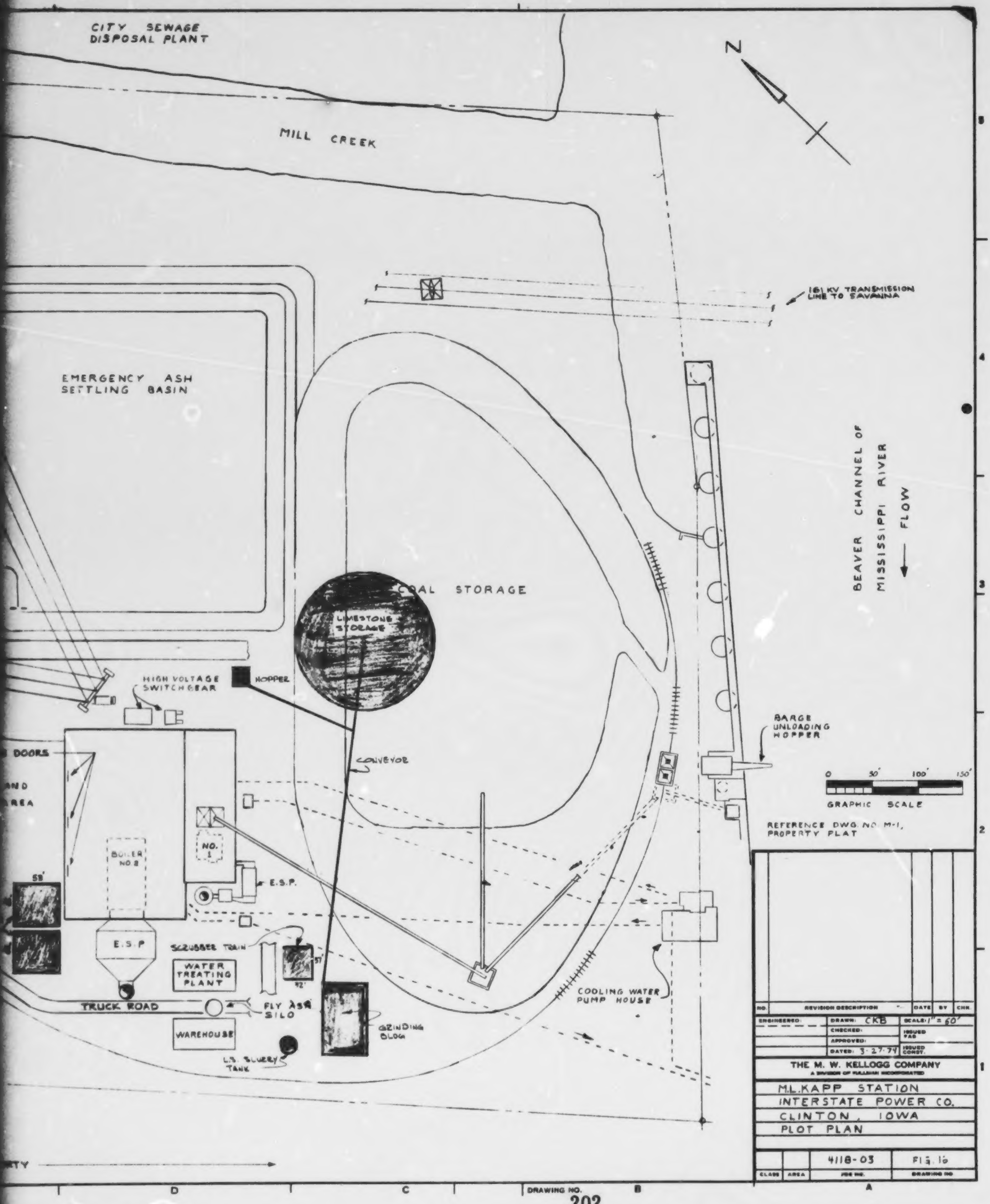
THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED

PLOT PLAN
IOWA SOUTHERN UTILITIES CO.
BURLINGTON STATION

CLASS	AREA	JOB NO.	DRAWING NO.
		4118-08	FIG. 15


CITY SEWAG
DISPOSAL PLA
EMERGENCY ASH
SETTLING BASIN
161 KV
SUB STATION
CONTROL BLDG.
161 KV
SUB STATION
69 KV
SUB STATION
ASH SLUICE
PUMP HOUSE
HIGH VOLT
SWITCH
10" ASH SLUICE PIPELINE
PROPERTY LINE (TYP)
LARGE DOORS
PARKING AND
STORAGE AREA
OPEN MARSHY AREA
BOILER
NO 2
59'
SCRUBBER
TRAINS
(TYP)
E.S.P
TRUCK ROAD
THICKENER
DAVENPORT ROCK ISLAND & NORTH WESTERN RAILROAD
DU PONT PROPERTY
H
G
F
E
D

NOTES:
1. ▭ SHADED AREAS WITHIN HEAVY LINES ARE TO BE NEW EQUIPMENT
2. SEE STD SCRUBBER MODULE DWG
3. MOVE PORTION OF COAL STORAGE PILE FOR LOCATION OF LIMESTONE STORAGE (AREA NEEDED = 83,000 SQ FT)


CITY SEWAGE DISPOSAL PLANT
N
MILL CREEK
161 KV TRANSMISSION LINE TO SAVANNA
EMERGENCY ASH SETTLING BASIN
BEAVER CHANNEL OF MISSISSIPPI RIVER
FLOW
COAL STORAGE
LIMESTONE STORAGE
HOPPER
HIGH VOLTAGE SWITCHGEAR
DOORS
AND
AREA
CONVEYOR
BARGE UNLOADING HOPPER
0
50'
100'
150'
GRAPHIC SCALE
BOILER NO 2
NO. 1
E.S.P.
E.S.P
58'
SCRUBBER TRAIN
57'
42'
WATER TREATING PLANT
TRUCK ROAD
FLY ASH SILO
WAREHOUSE
GRINDING BLDG
L.S. SLURRY TANK
COOLING WATER PUMP HOUSE
RTY
D
C
B
A
5
4
3
2
1
DRAWING NO.

REFERENCE DWG. NO. M-1, PROPERTY PLAT

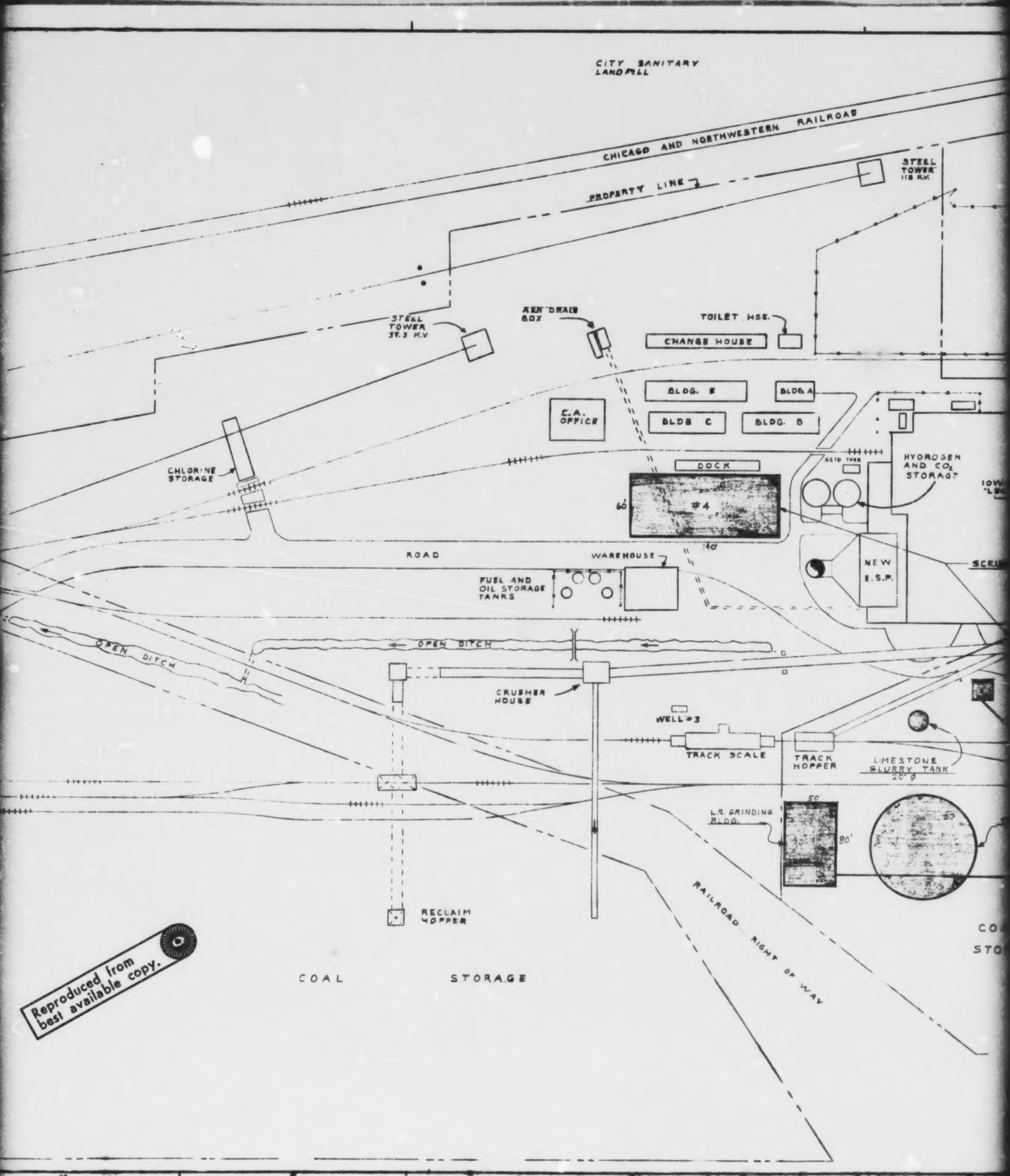
NO.	REVISION DESCRIPTION	DATE	BY	CHK.

ENGINEERED:
DRAWN: CKB
CHECKED:
APPROVED:
DATED: 3-27-74
SCALE: 1" = 60'
ISSUED FAB
ISSUED CONST.

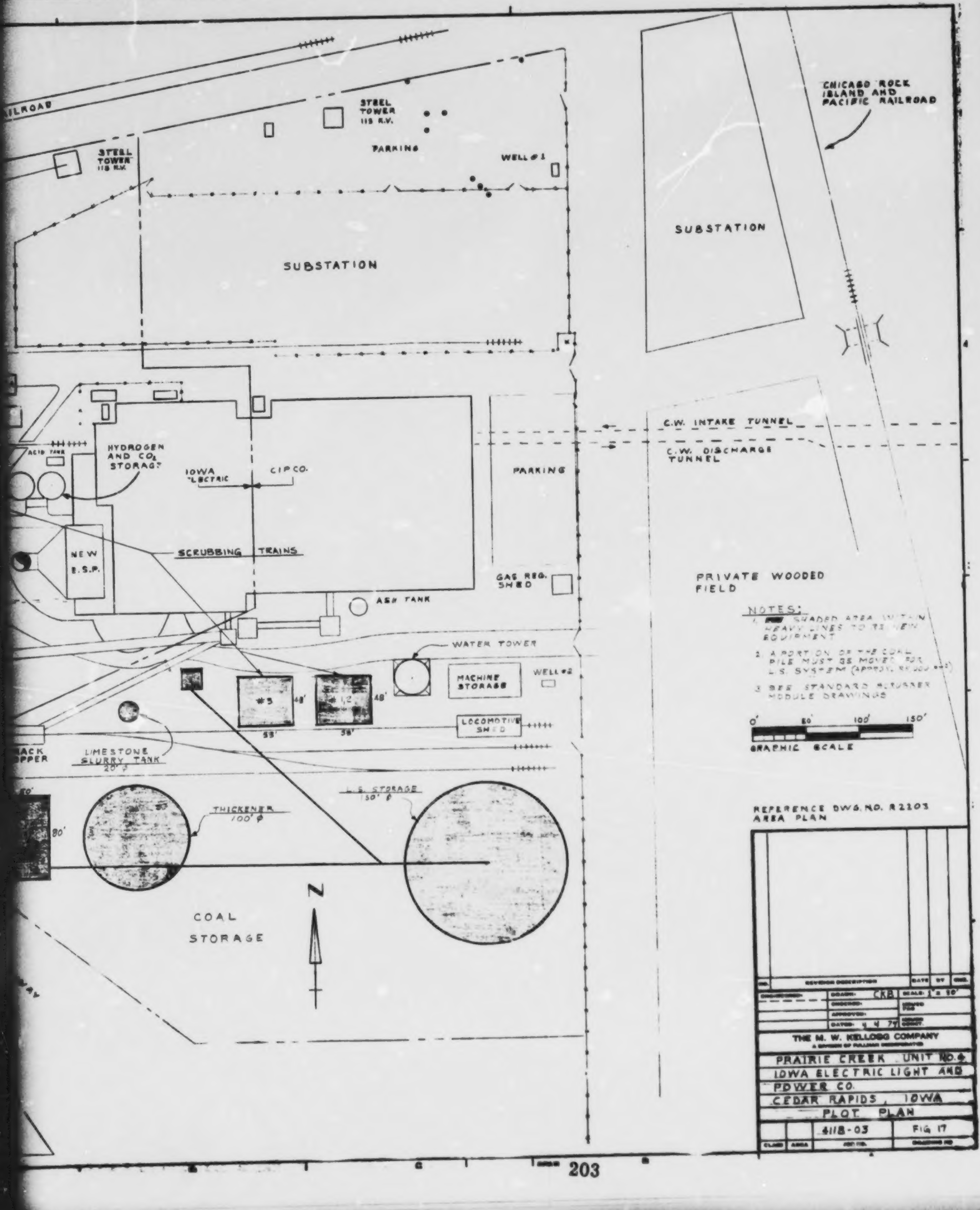
THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED

M.L. KAPP STATION
INTERSTATE POWER CO.
CLINTON, IOWA
PLOT PLAN

CLASS
AREA
JOB NO. 4118-03
DRAWING NO. FIG. 16


CITY SANITARY LANDFILL
CHICAGO AND NORTHWESTERN RAILROAD
PROPERTY LINE
STEEL TOWER 115 K.V.
STEEL TOWER 34.5 K.V
ASH DRAIN BOX
TOILET HSE.
CHANGE HOUSE
BLDG. E
BLDG. A
C.A. OFFICE
BLDG C
BLDG. D
CHLORINE STORAGE
DOCK
ACID TANK
HYDROGEN AND CO2 STORAGE
#4
60'
140'
ROAD
WAREHOUSE
FUEL AND OIL STORAGE TANKS
NEW E.S.P.
OPEN DITCH
OPEN DITCH
CRUSHER HOUSE
WELL #3
TRACK SCALE
TRACK HOPPER
LIMESTONE SLURRY TANK 20' ø
L.S. GRINDING BLDG.
50'
80'
RECLAIM HOPPER
RAILROAD RIGHT OF WAY
COAL STORAGE

Reproduced from best available copy.


RAILROAD
STEEL TOWER 115 KV.
STEEL TOWER 115 KV.
PARKING
WELL #1
CHICAGO ROCK ISLAND AND PACIFIC RAILROAD
SUBSTATION
SUBSTATION
HYDROGEN AND CO2 STORAGE
ACID TANK
IOWA ELECTRIC
CIPCO.
PARKING
C.W. INTAKE TUNNEL
C.W. DISCHARGE TUNNEL
NEW E.S.P.
SCRUBBING TRAINS
GAS REG. SHED
ASH TANK
PRIVATE WOODED FIELD
WATER TOWER
#3
48'
53'
#1,2
48'
58'
MACHINE STORAGE
WELL #2
LOCOMOTIVE SHED
TRACK HOPPER
LIMESTONE SLURRY TANK 20' ϕ
80'
80'
THICKENER 100' ϕ
L.S. STORAGE 150' ϕ
N
COAL STORAGE
0'
50'
100'
150'
GRAPHIC SCALE

NOTES:
1. ▇ SHADED AREA WITHIN HEAVY LINES TO BE NEW EQUIPMENT
2. A PORTION OF THE COAL PILE MUST BE MOVED FOR L.S. SYSTEM (APPROX. 50,000 [illegible])
3. SEE STANDARD SCRUBBER MODULE DRAWINGS

REFERENCE DWG. NO. R2203
AREA PLAN

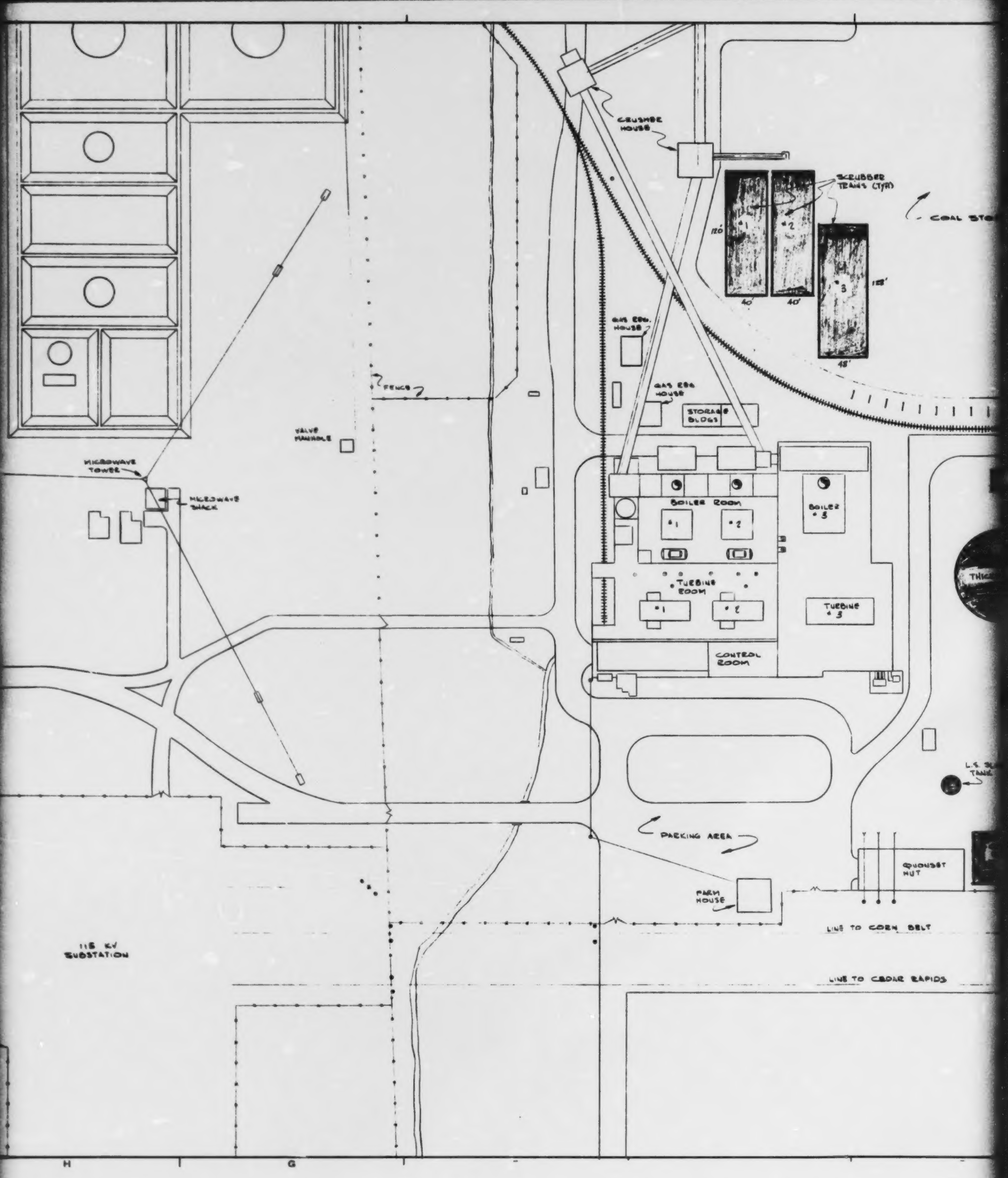
NO.	REVISION DESCRIPTION	DATE	BY	CHK.

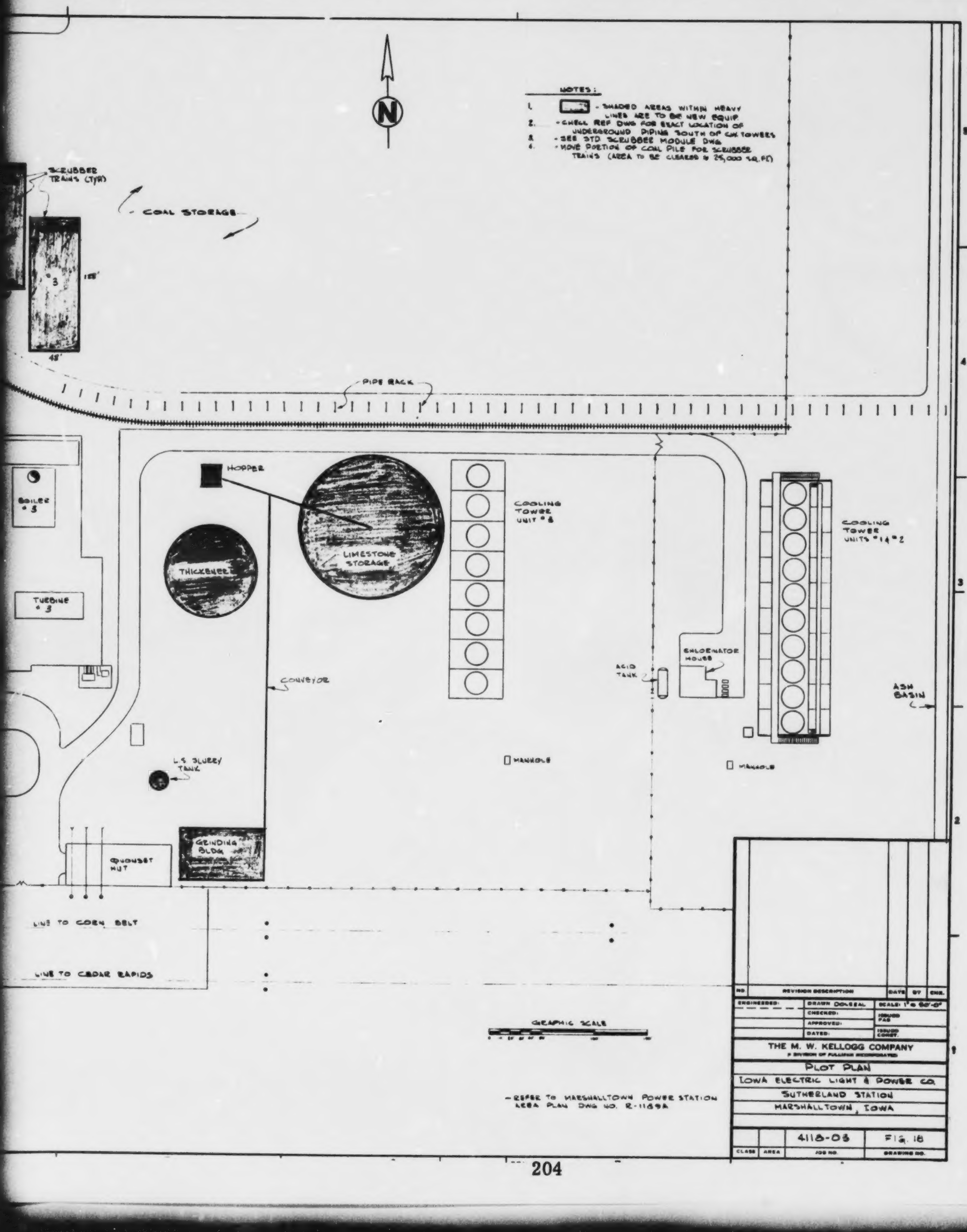
DRAWN: CKB
CHECKED:
APPROVED:
DATED: 4 4 79
SCALE: 1" = 50'

THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED

PRAIRIE CREEK UNIT NO. 4
IOWA ELECTRIC LIGHT AND POWER CO.
CEDAR RAPIDS, IOWA
PLOT PLAN

4118-03
FIG 17


CRUSHER HOUSE
SCRUBBER TRAINS (TYP.)
COAL STO
120'
#1
#2
#3
40'
40'
48'
128'
GAS REG. HOUSE
GAS REG. HOUSE
STORAGE BLDGS
FENCE
VALVE MANHOLE
MICROWAVE TOWER
MICROWAVE SHACK
BOILER ROOM
#1
#2
BOILER #3
TURBINE ROOM
#1
#2
TURBINE #3
CONTROL ROOM
THICK
L.S. SL
TANK
PARKING AREA
QUONSET HUT
FARM HOUSE
LINE TO CORN BELT
LINE TO CEDAR RAPIDS
115 KV SUBSTATION
H
G


N
SCRUBBER TRAINS (TYP)
COAL STORAGE
3
155'
45'
PIPE RACK
BOILER 3
TURBINE 3
HOPPER
THICKENER
LIMESTONE STORAGE
COOLING TOWER UNIT 3
COOLING TOWER UNITS 1 & 2
ACID TANK
CHLORINATOR HOUSE
ASH BASIN
CONVEYOR
L.S. SLURRY TANK
MANHOLE
MANHOLE
GRINDING BLDG
QUONSET HUT
LINE TO CORN BELT
LINE TO CEDAR RAPIDS
GRAPHIC SCALE
5
4
3
2
1

NOTES:

1. ▭ - SHADED AREAS WITHIN HEAVY LINES ARE TO BE NEW EQUIP.
2. ---- - CHECK REF DWG FOR EXACT LOCATION OF UNDERGROUND PIPING SOUTH OF C.W. TOWERS
3. - SEE STD SCRUBBER MODULE DWG
4. - MOVE PORTION OF COAL PILE FOR SCRUBBER TRAINS (AREA TO BE CLEARED ≈ 25,000 SQ.FT)

- REFER TO MARSHALLTOWN POWER STATION AREA PLAN DWG NO. R-1169A

NO.	REVISION DESCRIPTION	DATE	BY	CHK.

ENGINEERED:	DRAWN DOLEZAL	SCALE: 1" = 50'-0"
	CHECKED:	ISSUED FAB
	APPROVED:	
	DATED:	ISSUED CONST.

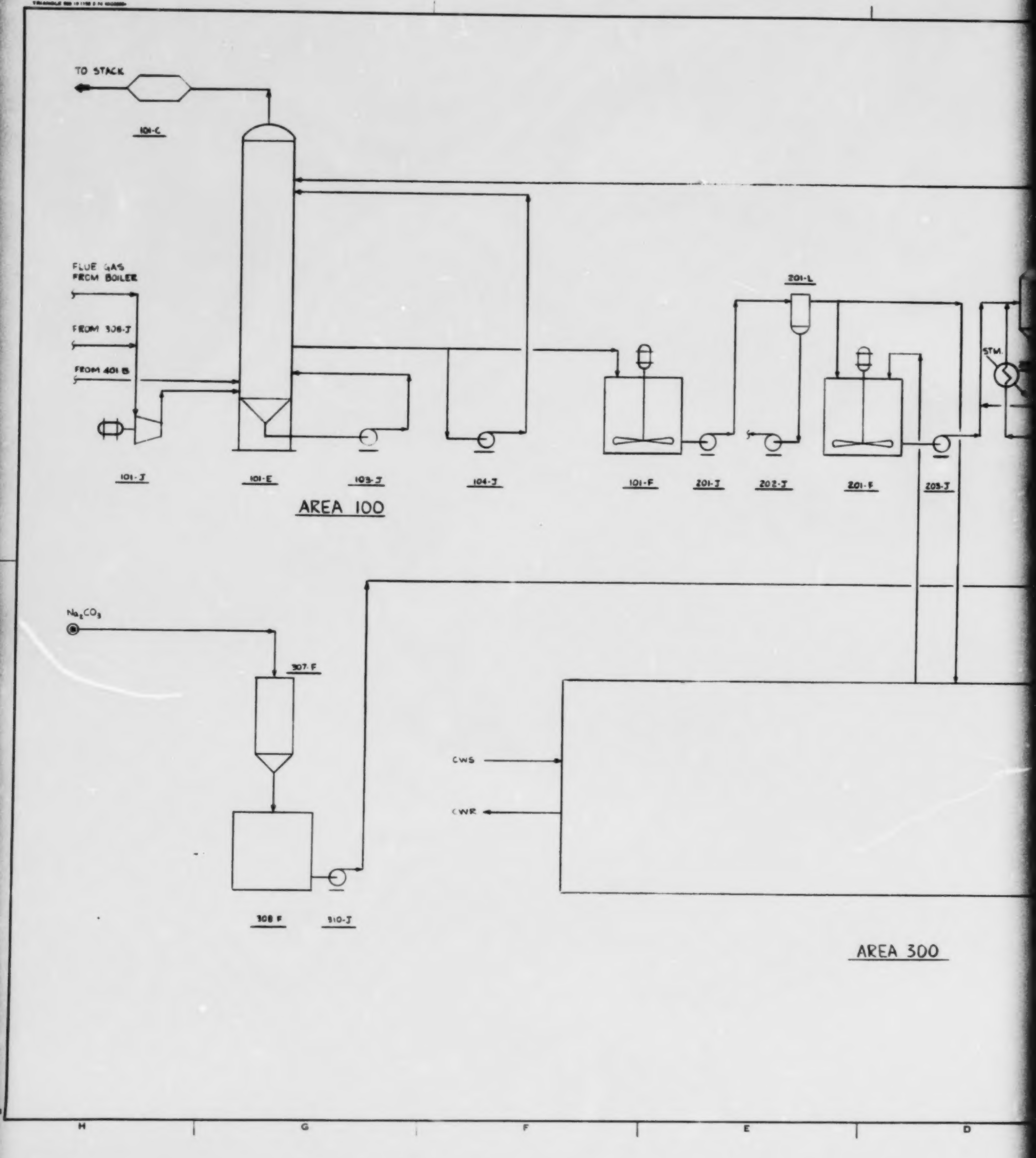
THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED

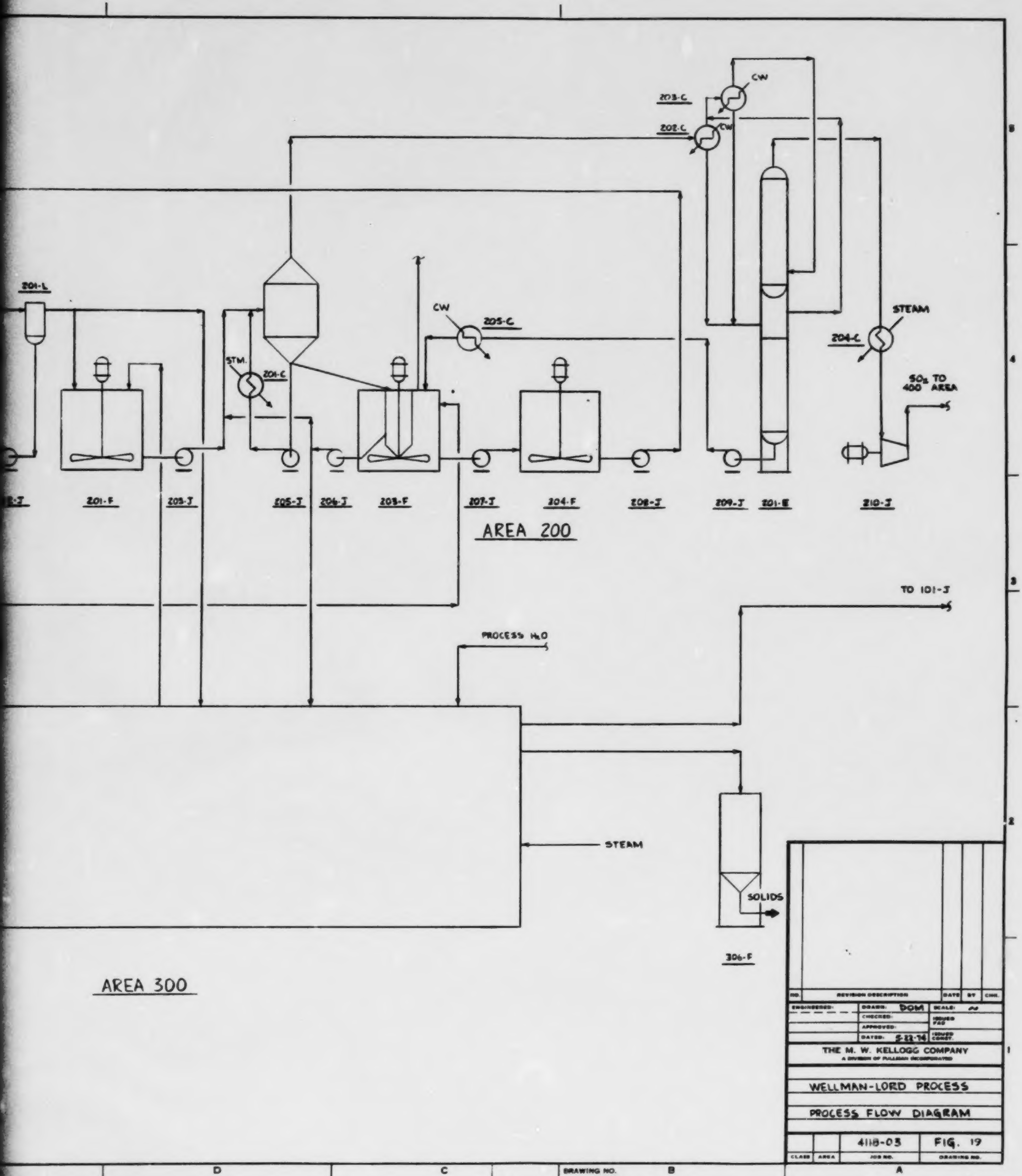
PLOT PLAN
IOWA ELECTRIC LIGHT & POWER CO.
SUTHERLAND STATION
MARSHALLTOWN, IOWA

CLASS	AREA	JOB NO.	DRAWING NO.
		4118-03	FIG. 18

APPENDIX C

WELLMAN-LORD/ALLIED SYSTEM


TO STACK
101-C
FLUE GAS FROM BOILER
FROM 306-J
FROM 401 B
101-J
101-E
103-J
104-J
AREA 100
101-F
201-J
202-J
201-L
201-F
203-J
STM.
Na_2CO_3
307-F
308 F
310-J
CWS
CWR
AREA 300
H
G
F
E
D


203-C
CW
202-C
CW
201-L
STM.
201-C
CW
205-C
STEAM
204-C
SO₂ TO 400 AREA
2-J
201-F
203-J
205-J
206-J
203-F
207-J
204-F
208-J
209-J
201-E
210-J
AREA 200
TO 101-J
PROCESS H₂O
STEAM
SOLIDS
306-F
AREA 300
D
C
B
A
5
4
3
2
1

NO.	REVISION DESCRIPTION	DATE	BY	CHK.

ENGINEERED:
DRAWN: DOM
CHECKED:
APPROVED:
DATED: 5-22-74
SCALE: ~
ISSUED FAB
ISSUED CONST.

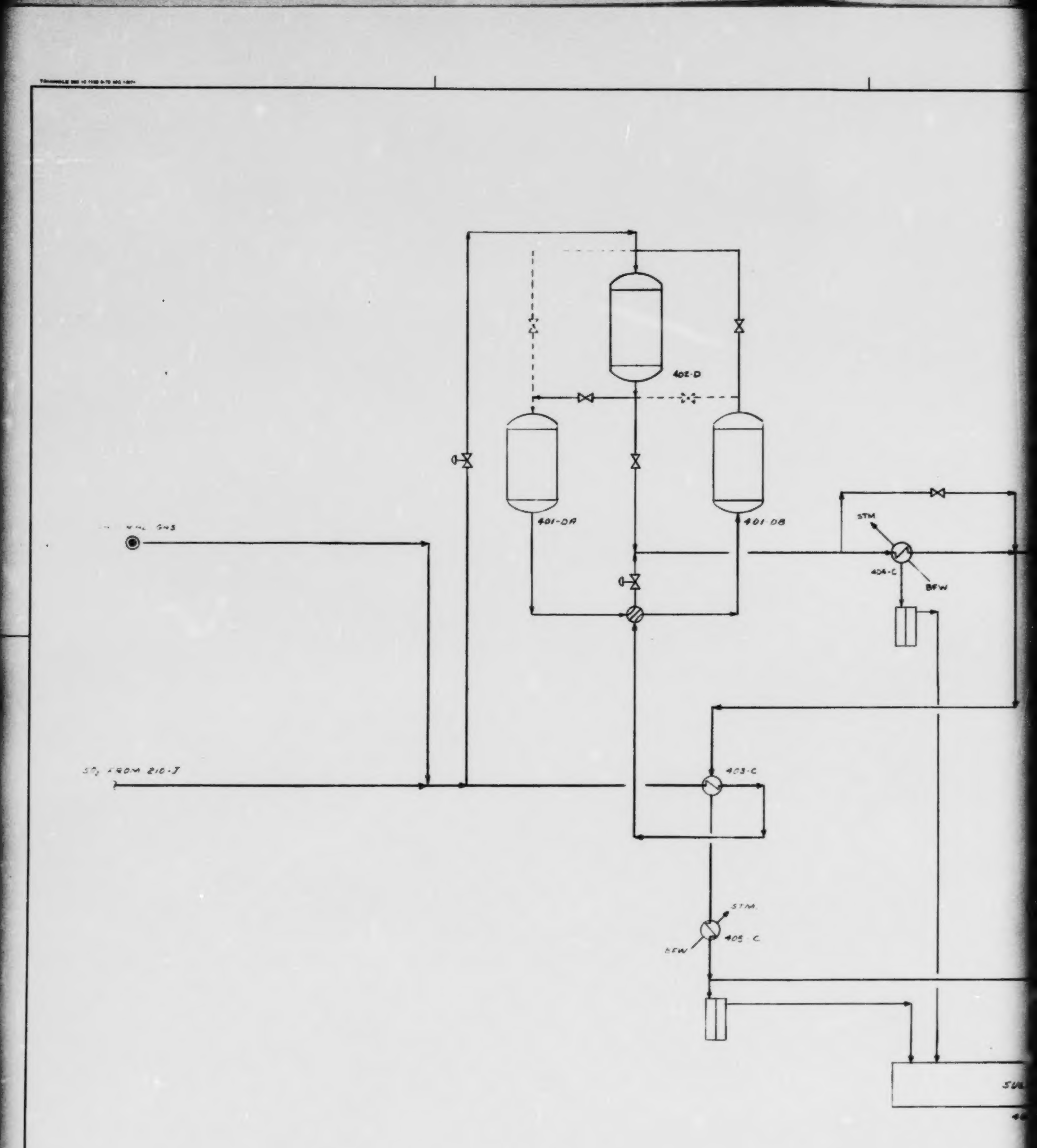
THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED

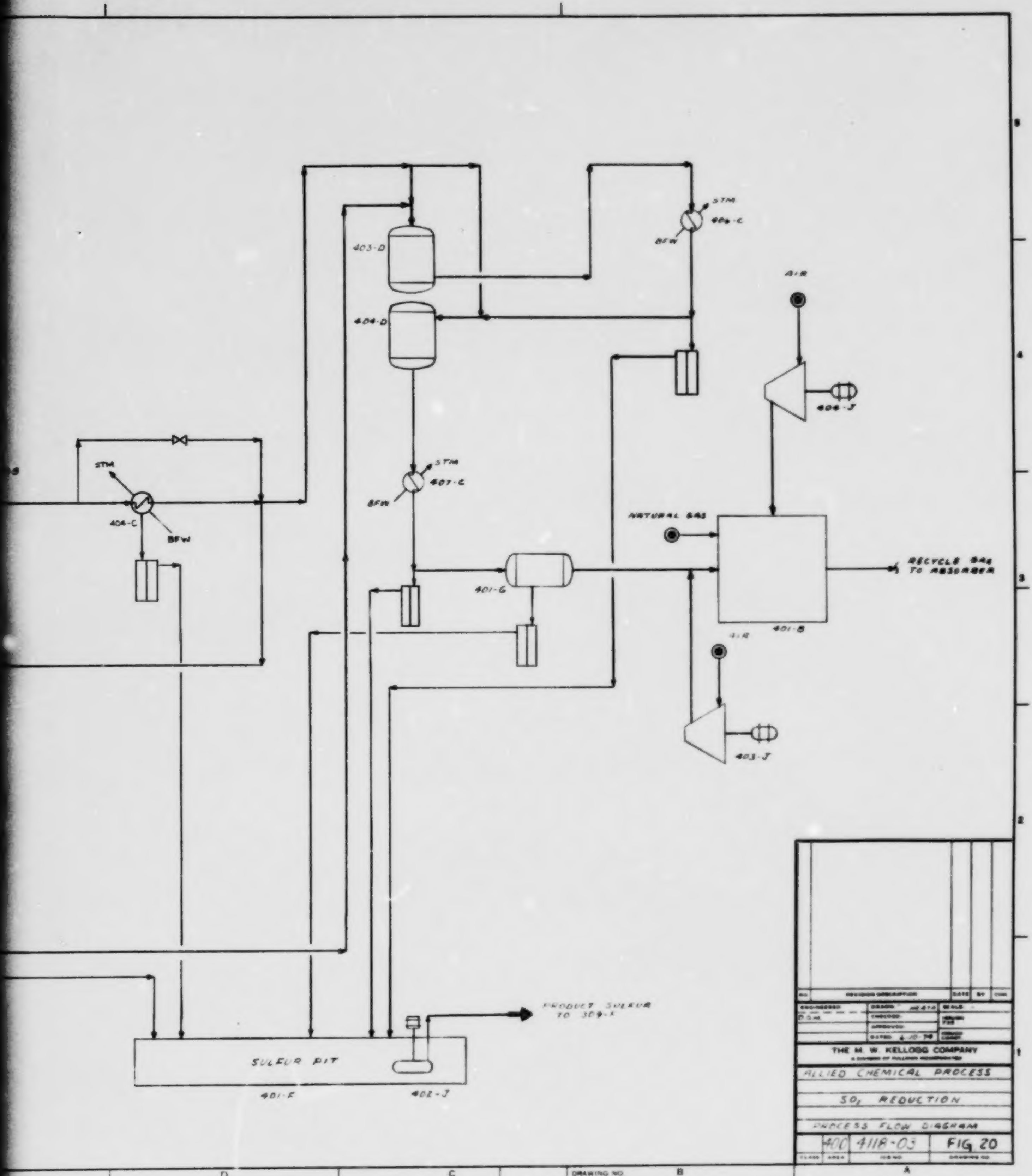
WELLMAN-LORD PROCESS

PROCESS FLOW DIAGRAM

CLASS	AREA	JOB NO.	DRAWING NO.
		4118-03	FIG. 19

DRAWING NO.


402-D
401-DA
401-DB
GAS
STM
404-C
BFW
SO_2 FROM 210-J
403-C
STM.
405-C
BFW
SUL
40
D
H
G
F
E
D


403-D
404-D
STM
406-C
BFW
AIR
404-J
STM
404-C
BFW
STM
407-C
BFW
NATURAL GAS
401-G
RECYCLE GAS TO ABSORBER
AIR
401-B
403-J
SULFUR PIT
401-F
402-J
PRODUCT SULFUR TO 309-F
D
C
B
A

THE M. W. KELLOGG COMPANY

ALLIED CHEMICAL PROCESS

SO_2 REDUCTION

PROCESS FLOW DIAGRAM

400 4118-03 FIG 20

ENG PROJ 6 9-70

Table 25
EQUIPMENT LIST

JOB/EST. NO. 4118-03

CLIENT: EPA - Iowa Utilities Study
LOCATION: Wellman-Lord/Allied Process
TYPE UNIT: Scrubbing Train: Area 100

CLASS C,E,F,J
PAGE NO.: 1 OF 6

ITEM NO.	DESCRIPTION EQUIPMENT TYPE: C-Heat Exchangers	ITEM CHANGED (✓)	ISSUE NO.
101-C	Reheater		
	E-Towers		
101-E	Absorber		
	F-Drums & Tanks		
101-F	Absorber Surge Tank		
	J-Pumps, Compressors, Blowers, Drivers		
101-J	Booster Fan		
102-J	Quench Pumps		
103-J	Prescrubber Circ. Pumps		
104-J	Absorber Circ. Pumps		

CHECKS IN FAR RIGHT HAND COLUMN INDICATE ITEMS CHANGED IN LATEST ISSUE.

STANDARD DISTRIBUTION (ENTIRE EQUIPMENT LIST)						ADDITIONAL DISTRIB. THIS SHEET ONLY	
DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.	ATTENTION OF:
DESIGN	PIPING DESIGN		CIVIL-MECH.	STANDARDS & SPECS.		PURCHASING AGENT	
	PLANT LAYOUT			CIVIL ENG.			
	MATERIAL CONTROL			FURNACE-EXCH. DIV.			
	PIPE SUPPORTS			MECHANICAL ENG. DIV.			
	PIPING INSTRUMENT		ESTIMATING SERVICES				
	LIGHT & POWER		SCHEDULING SERVICES				
	ELECTRICAL INSTRUMENT		COST	HOME OFFICE			
SYSTEMS	SYSTEMS ENG.			FIELD			
	INSTRUMENT ENG.		COST SERVICES				
	EQUIPMENT ENG.		PROCESS MGR.				

ISSUE NO.	1	2	3	4	5	6	7	8	9	10	11	12
DATE												

ENG PROJ 6 8-70

EQUIPMENT LIST

JOB/EST. NO.

CLIENT:

LOCATION:

TYPE UNIT: Regeneration Section: Area 200

CLASS C,E,F,J

PAGE NO.: 2 OF 6

ITEM NO.	DESCRIPTION EQUIPMENT TYPE: C-Exchangers & Condensers	ITEM CHANGED (✓)	ISSUE NO.
201-C	Evaporater Heater		
202-C	Primary Condenser		
203-C	Secondary Condenser		
204-C	SO_2 Superheater		
205-C	Condensate Cooler		
	E- Towers		
201-E	Condensate Stripper		
	F-Drums & Tanks		
201-F	Evaporator Feed Tank		
202-F	Evaporator		
203-F	Dump/Dissolving Tank		
204-F	Absorber Feed Tank		
	J-Pumps, Compressors, Blowers, & Drivers		
201-J	Filter Feed Pumps		
202-J	Flyash Filter Sump Pumps		
203-J	Evaporator Feed Pumps		
204-J	Evaporator Condensate Pumps		
205-J	Evaporator Circulating Pump		
206-J	Mother Liquor Pumps		
207-J	Transfer Pumps		
208-J	Absorber Feed Pumps		
209-J	Condensate Stripper Pumps		
210-J	SO_2 Compressor		

CHECKS IN FAR RIGHT HAND COLUMN INDICATE ITEMS CHANGED IN LATEST ISSUE.

STANDARD DISTRIBUTION (ENTIRE EQUIPMENT LIST)						ADDITIONAL DISTRIB. THIS SHEET ONLY	
DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.	ATTENTION OF:
DESIGN	PIPING DESIGN		CIVIL-MECH.	STANDARDS & SPECS.		PURCHASING AGENT	
	PLANT LAYOUT			CIVIL ENG.			
	MATERIAL CONTROL			FURNACE-EXCH. DIV.			
	PIPE SUPPORTS			MECHANICAL ENG. DIV.			
	PIPING INSTRUMENT		ESTIMATING SERVICES				
	LIGHT & POWER		SCHEDULING SERVICES				
	ELECTRICAL INSTRUMENT		COST	HOME OFFICE			
SYSTEMS	SYSTEMS ENG.			FIELD			
	INSTRUMENT ENG.		COST SERVICES				
	EQUIPMENT ENG.		PROCESS MGR.				

ISSUE NO.	1	2	3	4	5	6	7	8	9	10	11	12
DATE												

ENG PROJ 6 8-70

EQUIPMENT LIST

JOB/EST. NO.

CLIENT:

LOCATION:

CLASS L

TYPE UNIT: Area 200 (Cont.)

PAGE NO.: 3 OF 6

ITEM NO.	DESCRIPTION EQUIPMENT TYPE: L-Special Equipment	ITEM CHANGED (✓)	ISSUE NO.
201-L	Flyash Filters		

CHECKS IN FAR RIGHT HAND COLUMN INDICATE ITEMS CHANGED IN LATEST ISSUE.

STANDARD DISTRIBUTION (ENTIRE EQUIPMENT LIST)						ADDITIONAL DISTRIB. THIS SHEET ONLY	
DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.	ATTENTION OF:
DESIGN	PIPING DESIGN		CIVIL-MECH	STANDARDS & SPECS.		PURCHASING AGENT	
	PLANT LAYOUT			CIVIL ENG.			
	MATERIAL CONTROL			FURNACE-EXCH. DIV.			
	PIPE SUPPORTS			MECHANICAL ENG. DIV.			
	PIPING INSTRUMENT		ESTIMATING SERVICES				
	LIGHT & POWER		SCHEDULING SERVICES				
	ELECTRICAL INSTRUMENT		CONST.	HOME OFFICE			
SYSTEMS	SYSTEMS ENG.			FIELD			
	INSTRUMENT ENG.		COST SERVICES				
	EQUIPMENT ENG.		PROCESS MGR.				

ISSUE NO.	1	2	3	4	5	6	7	8	9	10	11	12
DATE												

ENG PROJ 6 9-70

EQUIPMENT LIST

JOB/EST. NO.

CLIENT:

LOCATION:

TYPE UNIT: Purge/Make-Up Section: Area 300

CLASS F, J

PAGE NO.: 4 OF 6

ITEM NO.	DESCRIPTION EQUIPMENT TYPE: F-Drums & Tanks .	ITEM CHANGED (✓)	ISSUE NO.
306-F	Purge Solids Bin		
307-F	$Na_2 CO_3$ Bin		
308-F	$Na_2 CO_3$ Mix Tank		
	J- Pumps, Compressors, Blowers, & Drivers		
310-J	$Na_2 CO_3$ Pumps		

CHECKS IN FAR RIGHT HAND COLUMN INDICATE ITEMS CHANGED IN LATEST ISSUE.

STANDARD DISTRIBUTION (ENTIRE EQUIPMENT LIST)						ADDITIONAL DISTRIB. THIS SHEET ONLY	
DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.	ATTENTION OF:
DESIGN	PIPING DESIGN		CIVIL-MECH.	STANDARDS & SPECS.		PURCHASING AGENT	
	PLANT LAYOUT			CIVIL ENG.			
	MATERIAL CONTROL			FURNACE-EXCH. DIV.			
	PIPE SUPPORTS			MECHANICAL ENG. DIV.			
	PIPING INSTRUMENT		ESTIMATING SERVICES				
	LIGHT & POWER		SCHEDULING SERVICES				
	ELECTRICAL INSTRUMENT		CONST.	HOME OFFICE			
SYSTEMS	SYSTEMS ENG.			FIELD			
	INSTRUMENT ENG.		COST SERVICES				
	EQUIPMENT ENG.		PROCESS MGR.				

ISSUE NO.	1	2	3	4	5	6	7	8	[illegible]	10	11	12
DATE												

ENG PROJ 6 9-70

M KELLOGG W

EQUIPMENT LIST

JOB/EST. NO.

CLIENT:

LOCATION:

CLASS B

TYPE UNIT: SO$_2$ Reduction: 400

PAGE NO.: 5 OF 6

ITEM NO.	DESCRIPTION EQUIPMENT TYPE: B-Furnaces, Fired Heaters & Stacks	ITEM CHANGED (✓)	ISSUE NO.
401-B	Tail Gas Incinerator		

CHECKS IN FAR RIGHT HAND COLUMN INDICATE ITEMS CHANGED IN LATEST ISSUE.

STANDARD DISTRIBUTION (ENTIRE EQUIPMENT LIST)						ADDITIONAL DISTRIB. THIS SHEET ONLY	
DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.	ATTENTION OF:
DESIGN	PIPING DESIGN		CIVIL-MECH	STANDARDS & SPECS.		PURCHASING AGENT	
	PLANT LAYOUT			CIVIL ENG.			
	MATERIAL CONTROL			FURNACE-EXCH. DIV.			
	PIPE SUPPORTS			MECHANICAL ENG. DIV.			
	PIPING INSTRUMENT		ESTIMATING SERVICES				
	LIGHT & POWER		SCHEDULING SERVICES				
	ELECTRICAL INSTRUMENT		CONST.	HOME OFFICE			
SYSTEMS	SYSTEMS ENG.			FIELD			
	INSTRUMENT ENG.		COST SERVICES				
	EQUIPMENT ENG.		PROCESS MGR.				

ISSUE NO.	1	2	3	4	5	6	7	8	9	10	11	12
DATE												

ENG PROJ 6 9-70

EQUIPMENT LIST

JOB/EST. NO. ____________

CLIENT: ____________

LOCATION: ____________

TYPE UNIT: SO_2 Reduction: 400 (Cont.)

CLASS C,D,F,G,J

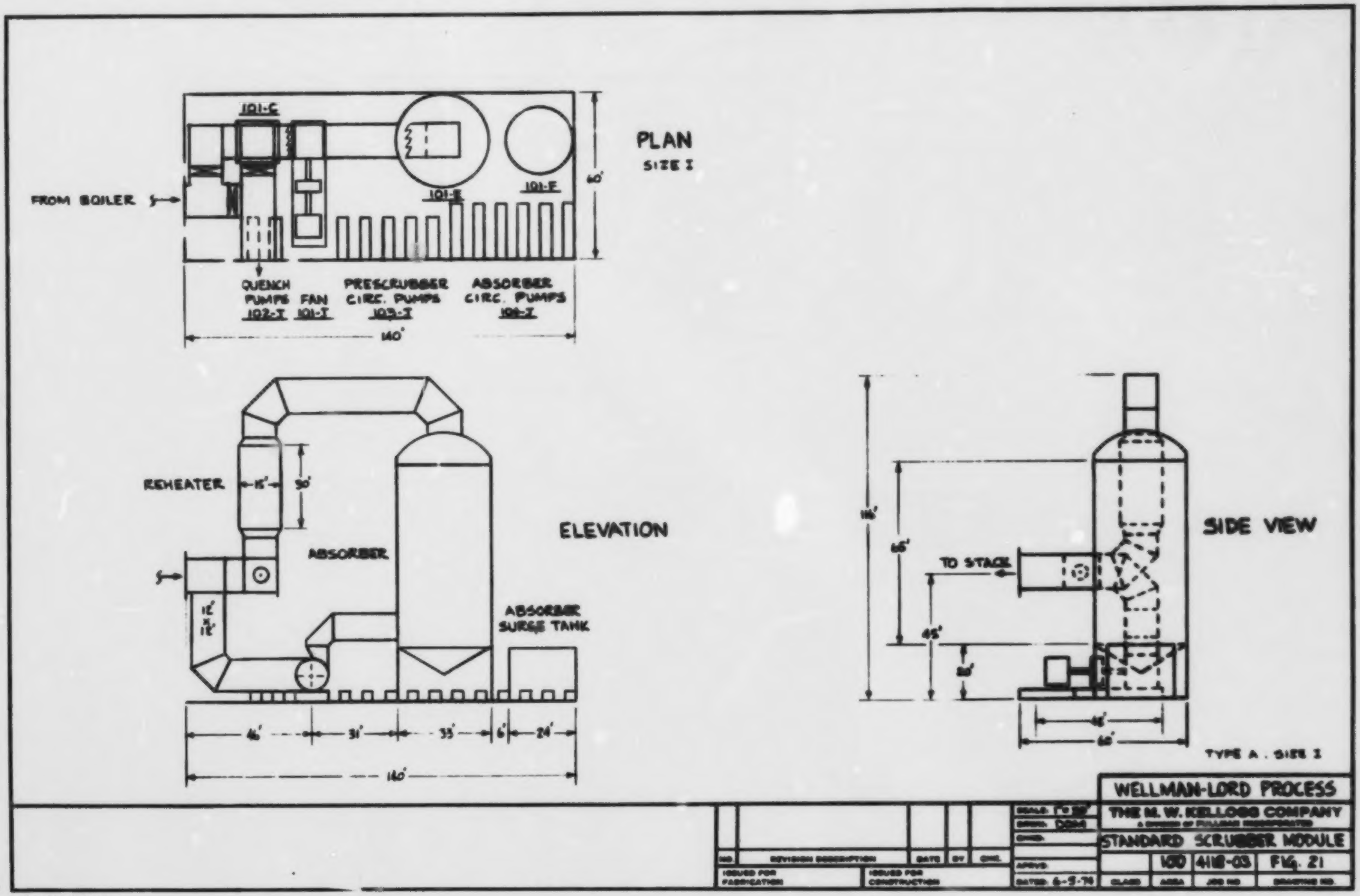
PAGE NO.: 6 OF 6

ITEM NO.	DESCRIPTION EQUIPMENT TYPE: C-Exchangers & Condensers	ITEM CHANGED (✓)	ISSUE NO.
403-C	Feed Preheater		
404-C	Mixed Gas Cooler		
405-C	1st Sulfur Condenser		
406-C	2nd Sulfur Condenser		
407-C	3rd Sulfur Condenser		
	D-Converters, Reactors, & Regenerators		
401-D	Heat Regenerators		
402-D	Reduction Reactor		
403-D	1st Claus Reactor		
404-D	2nd Claus Reactor		
	F-Drums & Tanks		
401-F	Sulfur Pit		
	G-Separators		
401-G	Tail Gas Mist Eliminator		
	J-Pumps, Compressors, Blowers, & Drivers		
402-J	Sulfur Pit Pumps		
403-J	Dilution Air Blowers		
404-J	Combustion Air Blowers		
405-J	Start-up Air Blower		

CHECKS IN FAR RIGHT HAND COLUMN INDICATE ITEMS CHANGED IN LATEST ISSUE.

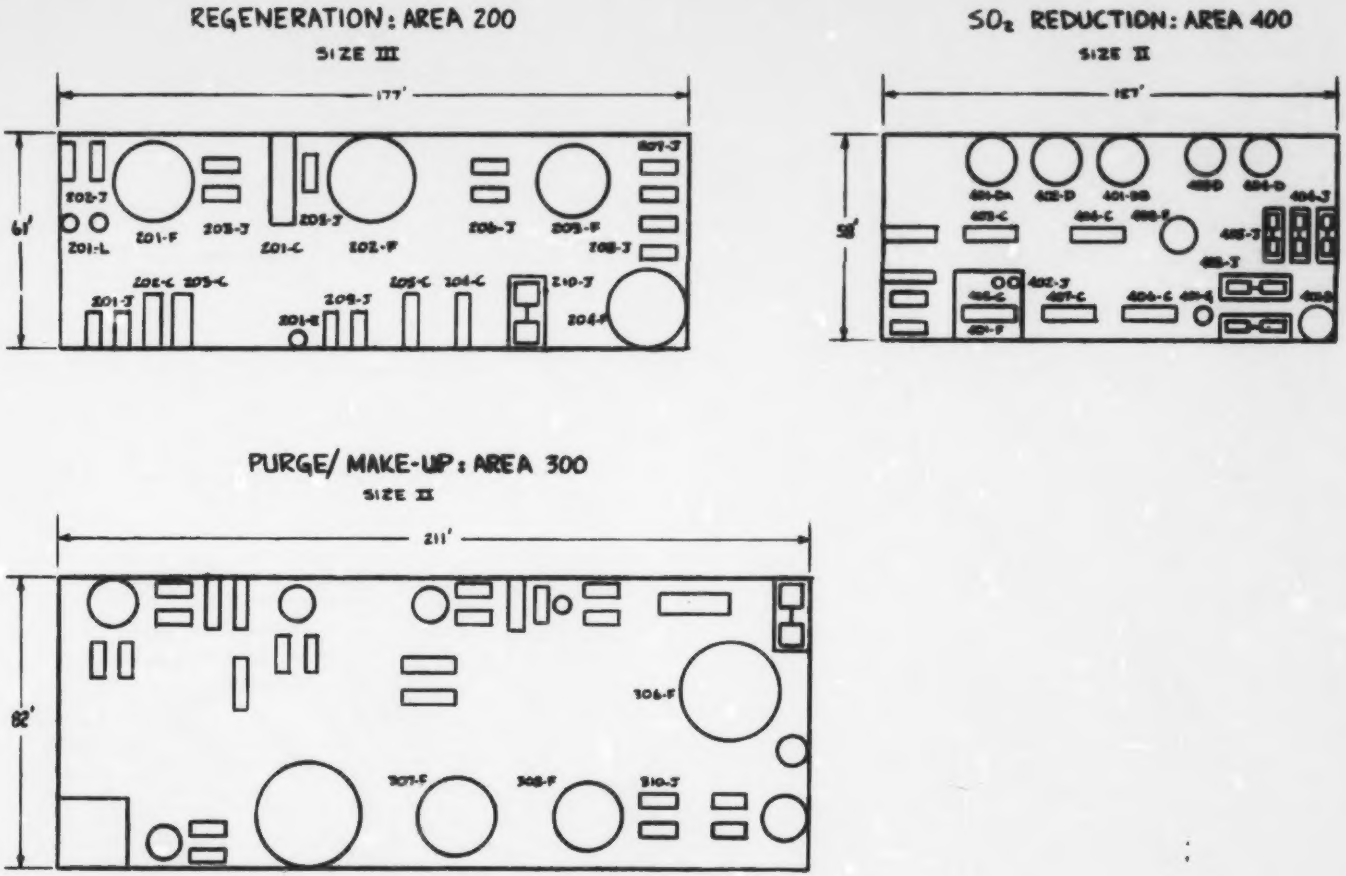
STANDARD DISTRIBUTION (ENTIRE EQUIPMENT LIST)						ADDITIONAL DISTRIB. THIS SHEET ONLY	
DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.	ATTENTION OF:
DESIGN	PIPING DESIGN		CIVIL-MECH	STANDARDS & SPECS.		PURCHASING AGENT	
	PLANT LAYOUT			CIVIL ENG.			
	MATERIAL CONTROL			FURNACE-EXCH. DIV.			
	PIPE SUPPORTS			MECHANICAL ENG. DIV.			
	PIPING INSTRUMENT		ESTIMATING SERVICES				
	LIGHT & POWER		SCHEDULING SERVICES				
	ELECTRICAL INSTRUMENT		CONST.	HOME OFFICE			
SYSTEMS	SYSTEMS ENG.			FIELD			
	INSTRUMENT ENG.		COST SERVICES				
	EQUIPMENT ENG.		PROCESS MGR.				

ISSUE NO.	1	2	3	4	5	6	7	8	9	10	11	12
DATE												



PLAN
SIZE I
101-C
101-E
101-F
FROM BOILER
60'
QUENCH PUMPS 102-I
FAN 101-I
PRESCRUBBER CIRC. PUMPS 103-I
ABSORBER CIRC. PUMPS 104-I
140'
ELEVATION
REHEATER
15'
30'
ABSORBER
12' x 12'
ABSORBER SURGE TANK
46'
31'
33'
6'
24'
140'
SIDE VIEW
116'
65'
45'
20'
TO STACK
48'
60'
TYPE A . SIZE I
WELLMAN-LORD PROCESS
THE M. W. KELLOGG COMPANY
STANDARD SCRUBBER MODULE
100
4118-03
FIG. 21
NO.
REVISION DESCRIPTION
DATE
BY
CHK.
ISSUED FOR FABRICATION
ISSUED FOR CONSTRUCTION
SCALE 1"=30'
DRWN. DDM
CHKD.
APPVD.
DATED 6-5-74
CLASS
AREA
JOB NO
DRAWING NO.

B
11 X 17


REGENERATION: AREA 200

SIZE III

SO₂ REDUCTION: AREA 400

SIZE II

PURGE/ MAKE-UP: AREA 300

SIZE II

177'
61'
202-J
201-L
201-F
203-J
201-C
205-J
202-F
206-J
203-F
207-J
208-J
210-J
204-F
201-J
202-C
203-C
201-E
209-J
205-C
204-C
157'
58'
401-DA
402-D
401-DB
403-D
404-D
404-J
403-C
404-C
408-F
405-J
403-J
402-J
406-C
401-F
407-C
406-C
401-E
403-G
211'
82'
306-F
307-F
308-F
310-J

WELLMAN-LORD/ALLIED PROCESS

THE M. W. KELLOGG COMPANY

A DIVISION OF PULLMAN INCORPORATED

STANDARD MODULE PLANS

NO.	REVISION DESCRIPTION	DATE	BY	CHK.
ISSUED FOR FABRICATION	ISSUED FOR CONSTRUCTION			

SCALE: 1" = 30'

DRAWN: DOM

CHKD:

APPVD:

DATED: 5-15-76

CLASS	AREA	JOB NO	DRAWING NO.
	200 300 400	4118-05	FIG. 22

Table 26
WELLMAN-LORD/ALLIED PROCESS
STANDARD SIZES

Scrubber Area

Size	I	II	III	IV	V	VI	VII	VIII
ACFM @ 300°F	545,000	477,000	409,000	341,000	273,000	204,000	136,000	90,900
Factor	1.0	0.875	0.750	0.625	0.500	0.375	0.250	0.167
Dimen.: Ft.	60x140	56x136	52x132	48x128	44x124	40x120	36x116	32x112

Regen. Area

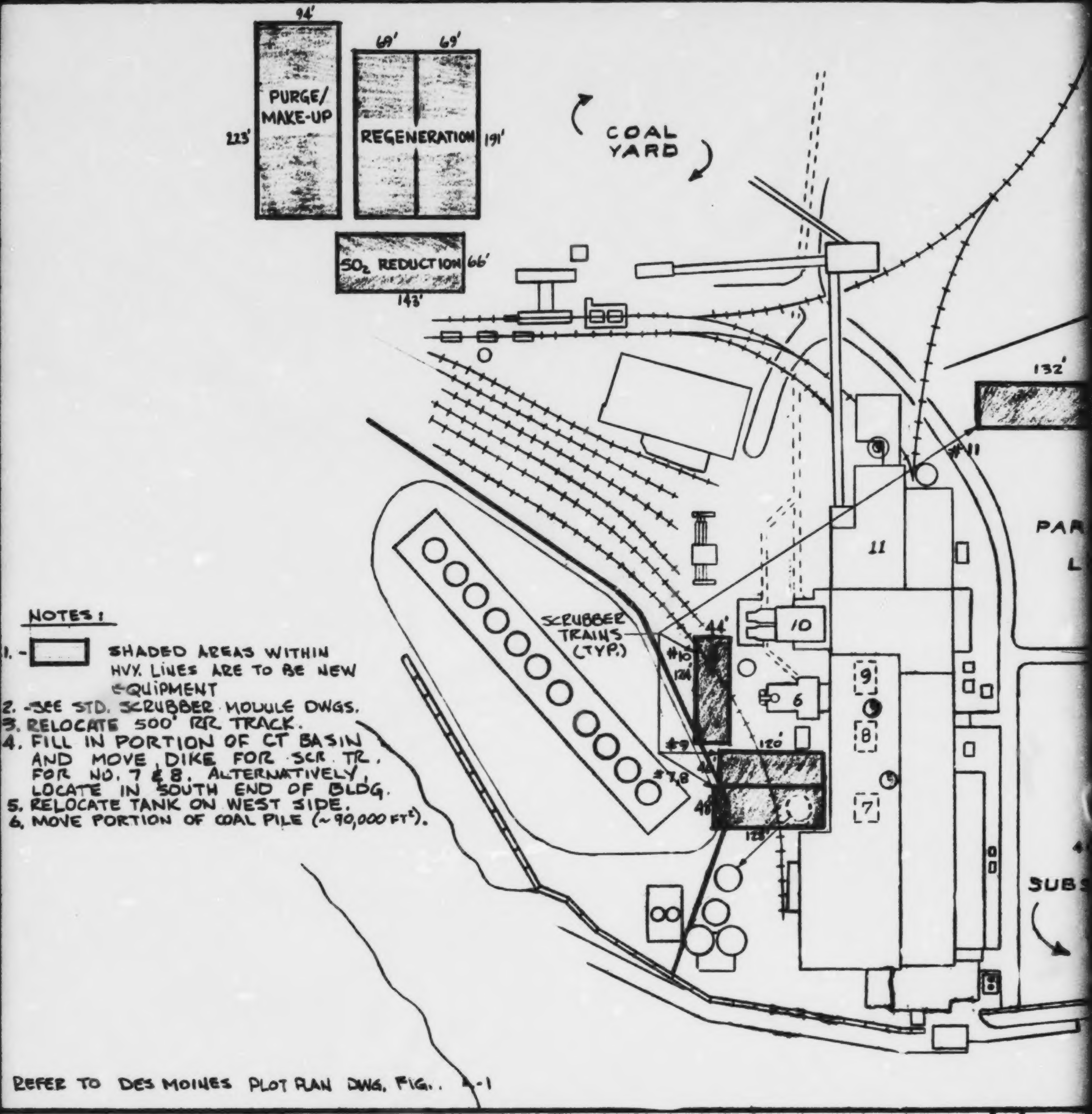
Size	I	II	III	IV	V	VI	VII	VIII
Sulfur Flow: lb/HR	9,000	8,000	7,000	6,000	5,000	4,000	3,000	2,000
Factor	1.000	0.889	0.778	0.667	0.555	0.444	0.333	0.222
Dimen.: Ft.	69x191	65x184	61x177	57x170	53x163	49x156	45x149	41x142

Purge/Make-Up Area

Size	I	II	III	IV	V	VI	VII	VIII
Sulfur Flow: lb/HR	18,000	14,000	10,000	7,000	5,000	4,000	3,000	2,000
Factor	1.000	0.778	0.555	0.389	0.278	0.222	0.167	0.111
Dimen.: Ft.	94x223	82x211	70x199	61x190	55x184	52x181	49x178	46x175

SO_2 Reduction Area

Size	I	II	III	IV	V	VI	VII	VIII
Sulfur Flow: lb/HR	18,000	14,000	10,000	7,000	5,000	4,000	3,000	2,000
Factor	1.000	0.778	0.555	0.389	0.278	0.222	0.167	0.111
Dimen.: Ft.	66x143	58x127	50x111	44x99	40x91	38x87	36x83	34x79


94'
69'
69'
PURGE/ MAKE-UP
223'
REGENERATION
191'
SO2 REDUCTION
66'
143'
COAL YARD
132'
#11
PAR
L
11
10
SCRUBBER TRAINS (TYP.)
44'
#10
124'
#9
6
9
8
7
120'
46'
46'
#7,8
128'
4
SUBS

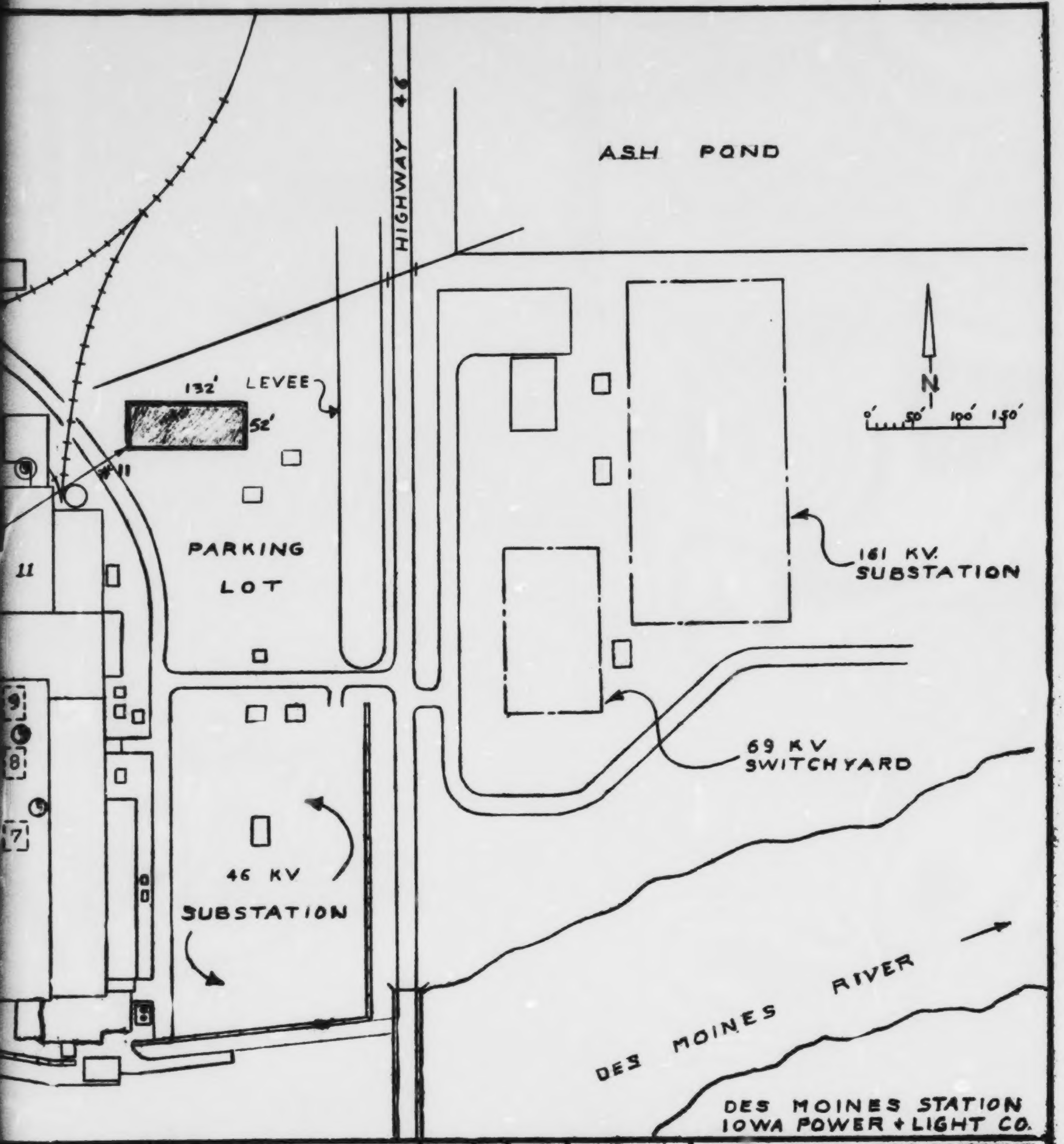
NOTES:

1. - ▭ SHADED AREAS WITHIN HVY. LINES ARE TO BE NEW EQUIPMENT
2. - SEE STD. SCRUBBER MODULE DWGS.
3. RELOCATE 500' RR TRACK.
4. FILL IN PORTION OF CT BASIN AND MOVE DIKE FOR SCR. TR. FOR NO. 7 & 8. ALTERNATIVELY, LOCATE IN SOUTH END OF BLDG.
5. RELOCATE TANK ON WEST SIDE.
6. MOVE PORTION OF COAL PILE (~90,000 FT²).

REFER TO DES MOINES PLOT PLAN DWG. FIG. 4-1

NO.

ISSUED FOR
FABRICATI


ASH POND
HIGHWAY 46
132'
LEVEE
52'
#11
PARKING LOT
11
9
8
7
46 KV SUBSTATION
69 KV SWITCHYARD
161 KV. SUBSTATION
N
0' 50' 100' 150'
DES MOINES RIVER
DES MOINES STATION
IOWA POWER + LIGHT CO.

SCALE:
DRWN: C.K.B.
CHKD:
APPRVD:
DATED:

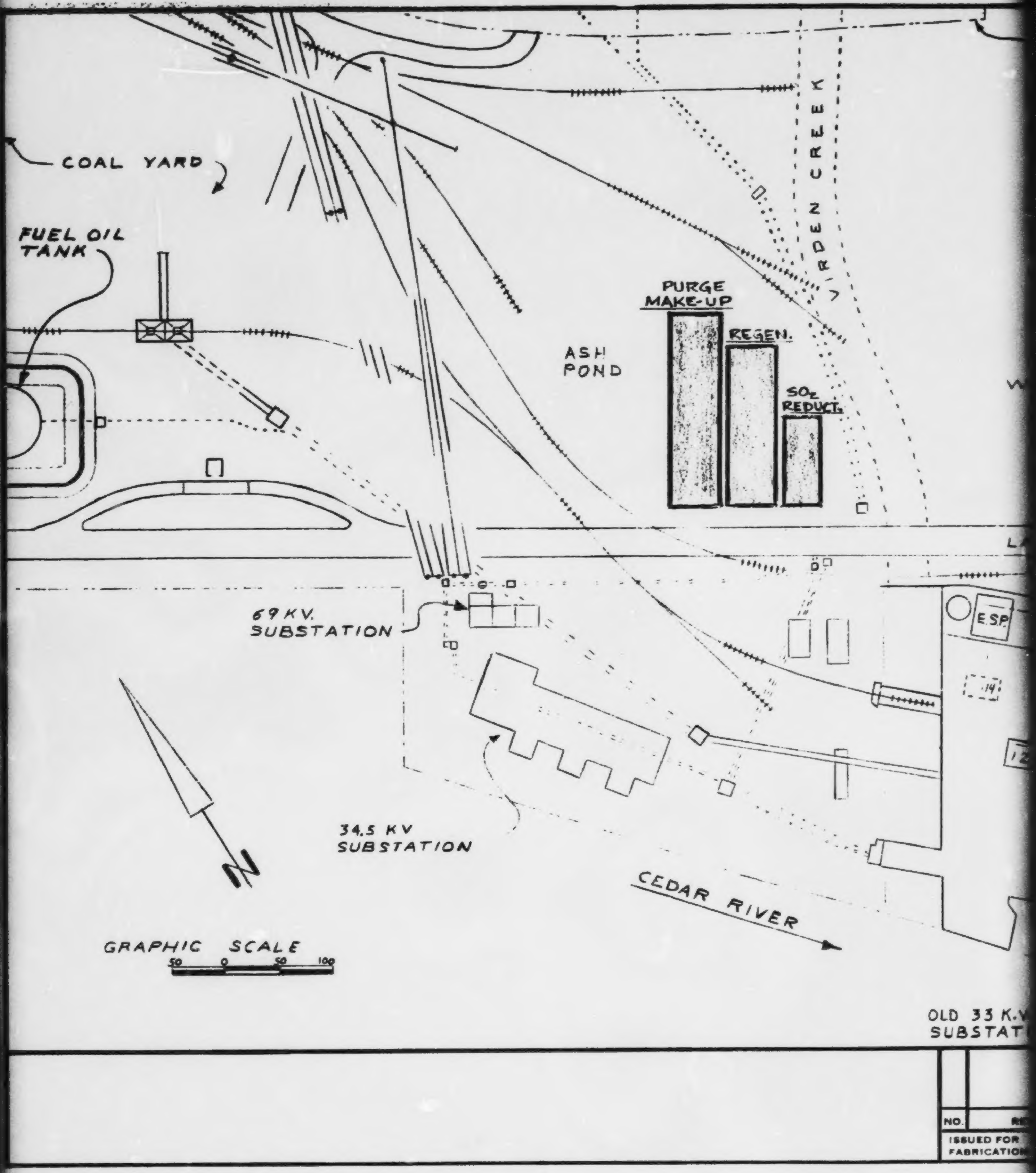
THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED

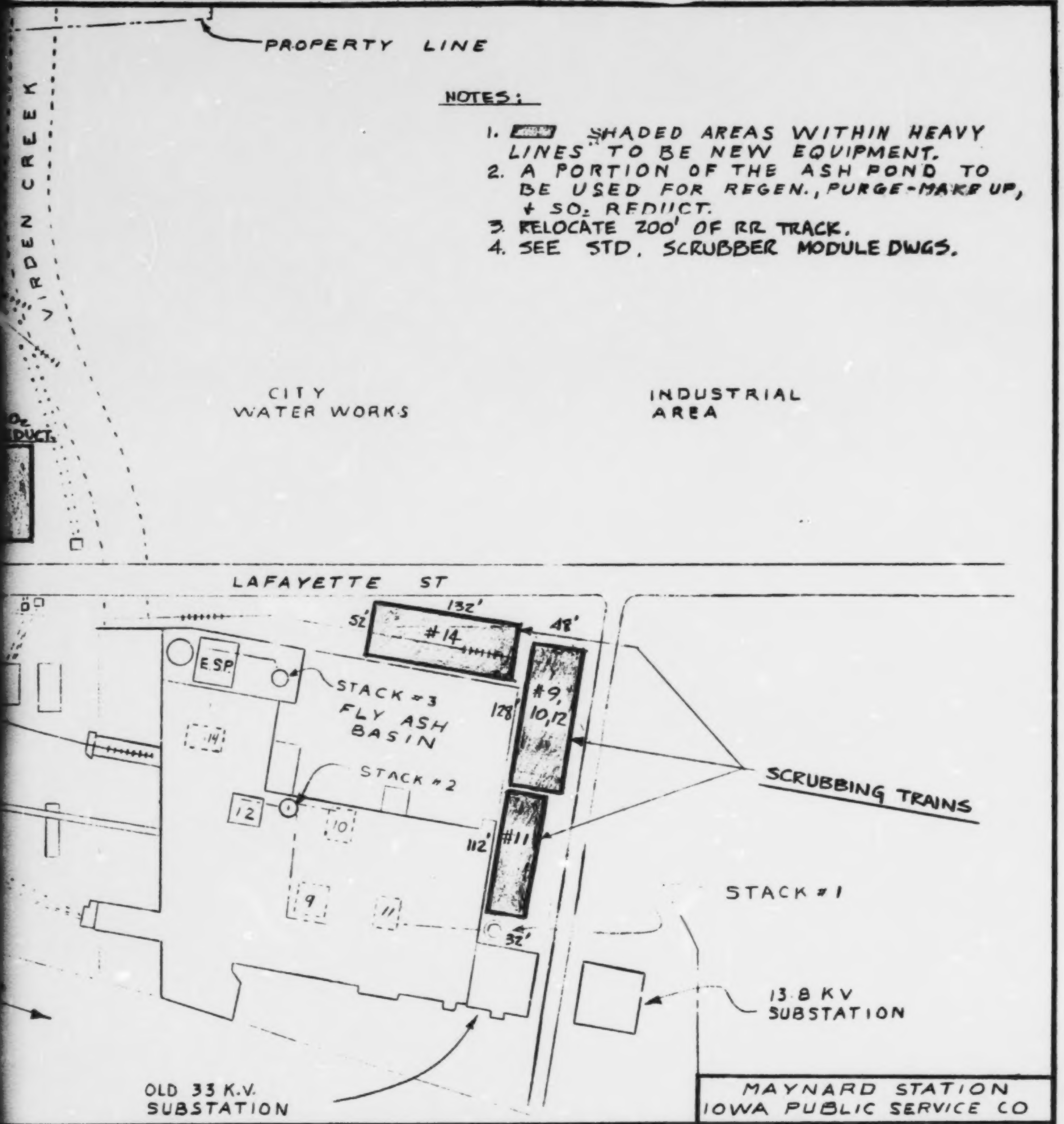
PLOT PLAN

NO.	REVISION DESCRIPTION	DATE	BY	CHK.

ISSUED FOR FABRICATION
ISSUED FOR CONSTRUCTION

CLASS	AREA	JOB NO.	DRAWING NO.
		4118-03	FIG. 23


COAL YARD
FUEL OIL TANK
PURGE MAKE-UP
REGEN.
SO2 REDUCT.
ASH POND
VIRDEN CREEK
W
LA
E.S.P.
14
12
69 K.V. SUBSTATION
34.5 KV SUBSTATION
CEDAR RIVER
N
GRAPHIC SCALE
50
0
50
100
OLD 33 K.V
SUBSTATI
NO.
RE
ISSUED FOR
FABRICATION


PROPERTY LINE
VIRDEN CREEK
SO2 REDUCT.
CITY WATER WORKS
INDUSTRIAL AREA
LAFAYETTE ST
132'
52'
#14
48'
E.S.P.
STACK #3
FLY ASH BASIN
14
128'
#9, 10,12
SCRUBBING TRAINS
STACK #2
12
10
112'
#11
9
11
32'
STACK #1
13.8 KV SUBSTATION
OLD 33 K.V. SUBSTATION

NOTES:

1. ▨ SHADED AREAS WITHIN HEAVY LINES TO BE NEW EQUIPMENT.
2. A PORTION OF THE ASH POND TO BE USED FOR REGEN., PURGE-MAKE UP, + SO_2 REDUCT.
3. RELOCATE 200' OF RR TRACK.
4. SEE STD. SCRUBBER MODULE DWGS.

MAYNARD STATION
IOWA PUBLIC SERVICE CO

THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED

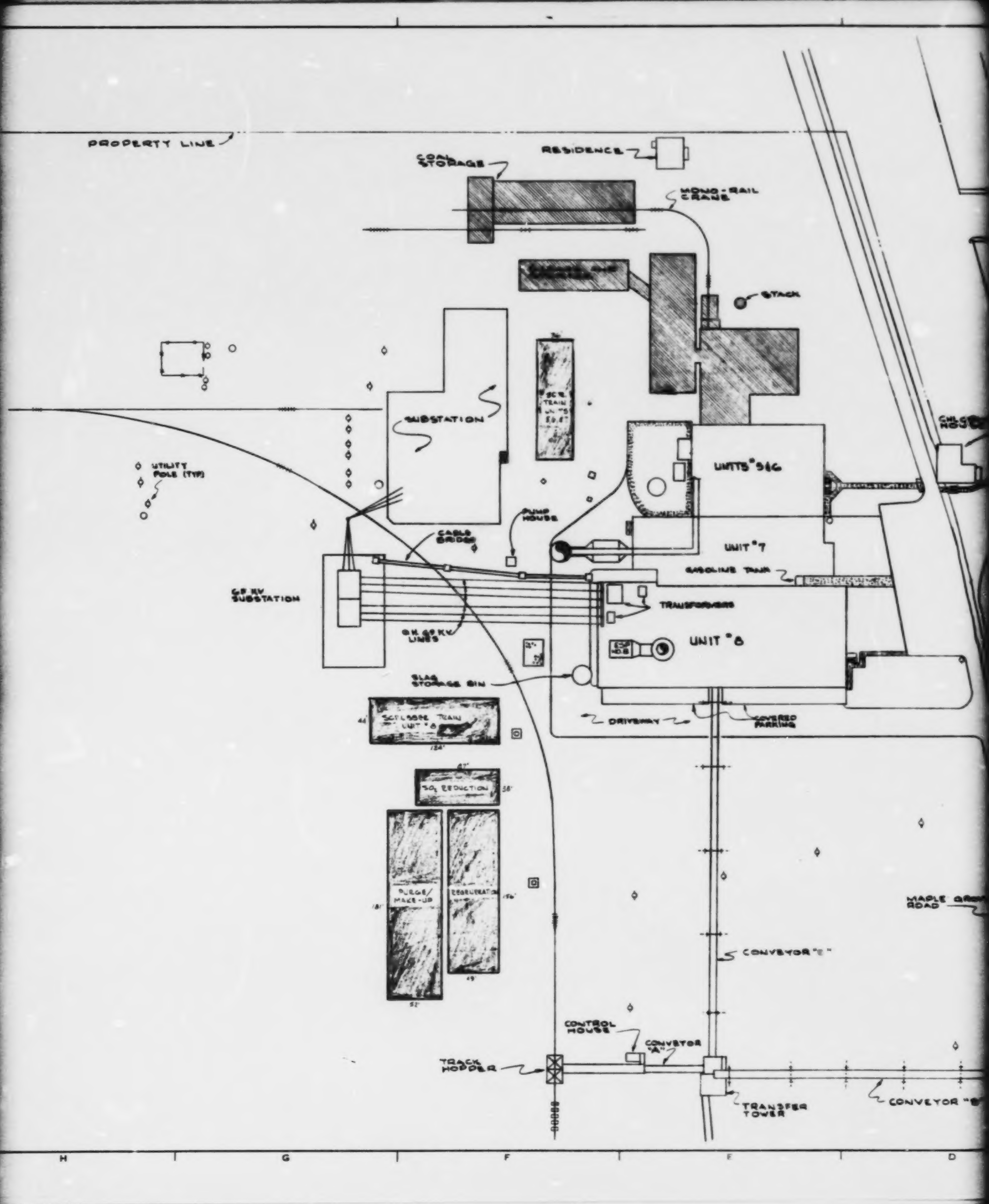
PLOT PLAN

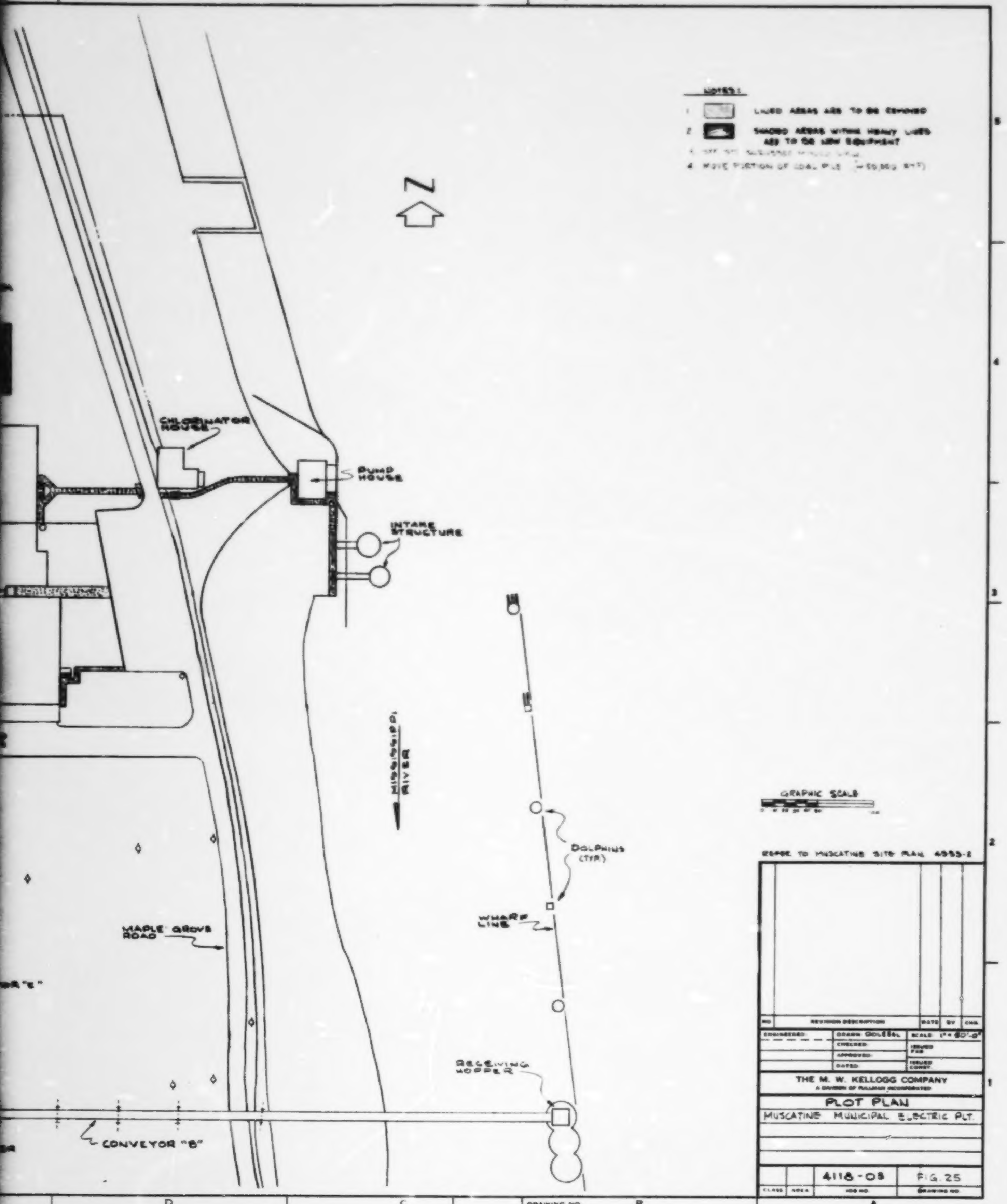
SCALE: 1" = 100'
DRWN: CKB
CHKD:
APRVD:
DATED:

NO.	REVISION DESCRIPTION	DATE	BY	CHK.

ISSUED FOR FABRICATION
ISSUED FOR CONSTRUCTION

CLASS	AREA	JOB NO.	DRAWING NO.
		4118-03	FIG. 24


PROPERTY LINE
COAL STORAGE
RESIDENCE
MONO-RAIL CRANE
STACK
UTILITY POLE (TYP)
SUBSTATION
SCR TRAIN UNITS 5 & 6
UNITS #5 & 6
PUMP HOUSE
CABLE BRIDGE
UNIT #7
GASOLINE TANK
69 KV SUBSTATION
TRANSFORMERS
OH 69 KV LINES
UNIT #8
SLAG STORAGE BIN
DRIVEWAY
COVERED PARKING
SCRUBBER TRAIN UNIT #8
44'
124'
67'
SO2 REDUCTION
38'
PURGE/MAKE-UP
REGENERATION
181'
156'
52'
49'
CONVEYOR "C"
MAPLE GROVE ROAD
CONTROL HOUSE
CONVEYOR "A"
TRACK HOPPER
TRANSFER TOWER
CONVEYOR "B"
H
G
F
E
D



NOTES:
1 LINED AREAS ARE TO BE REMOVED
2 SHADED AREAS WITHIN HEAVY LINES ARE TO BE NEW EQUIPMENT
3 [illegible]
4 MOVE PORTION OF COAL PILE (≈50,000 ?T)
N
CHLORINATOR HOUSE
PUMP HOUSE
INTAKE STRUCTURE
MISSISSIPPI RIVER
DOLPHINS (TYP)
WHARF LINE
MAPLE GROVE ROAD
RECEIVING HOPPER
CONVEYOR "B"
OR "E"
GRAPHIC SCALE
D
C
B
A
1
2
3
4
5

REFER TO MUSCATINE SITE PLAN 4553-1

NO	REVISION DESCRIPTION	DATE	BY	CHK

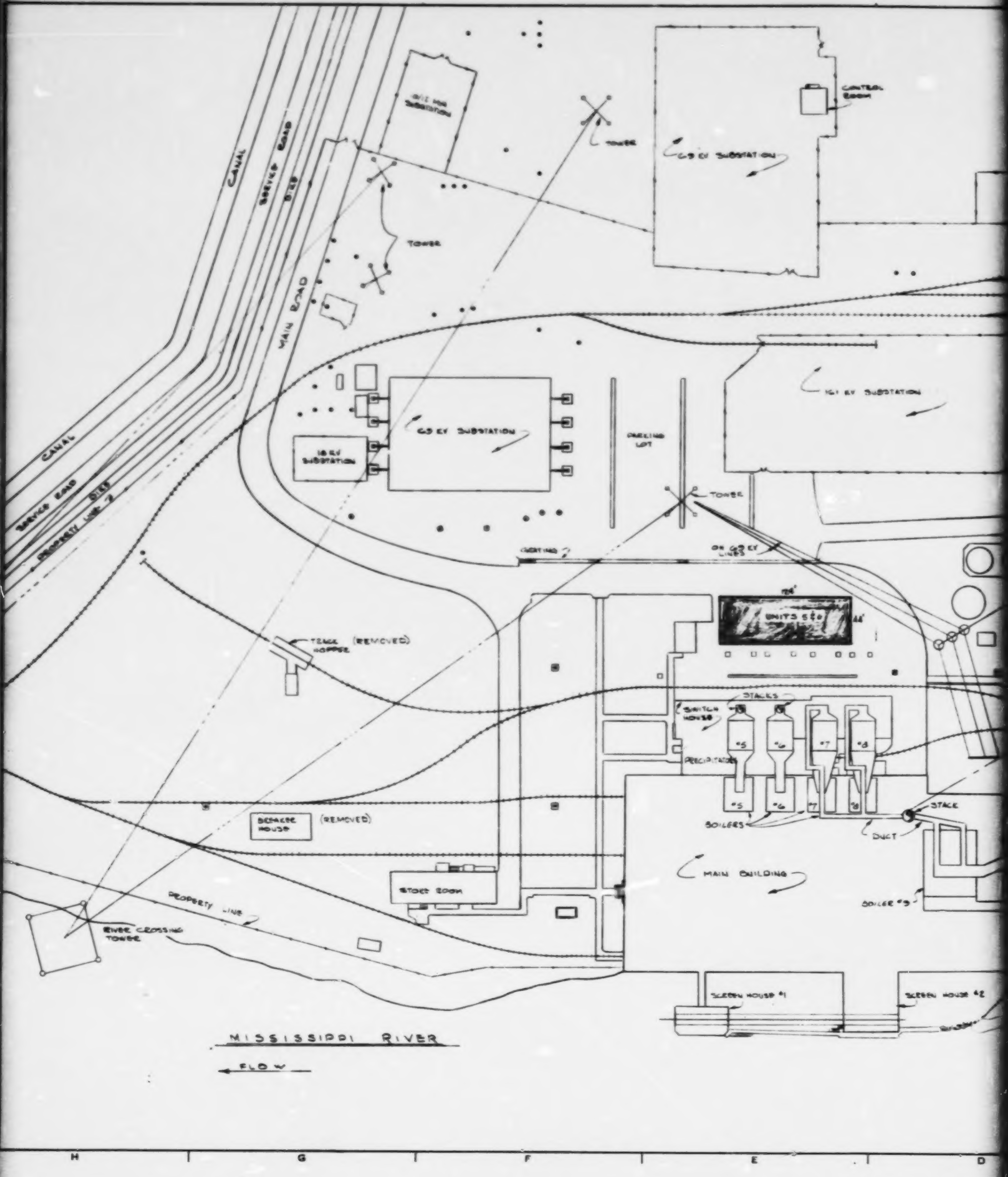
ENGINEERED
DRAWN DOLEŽAL
CHECKED
APPROVED
DATED
SCALE 1" = 50'-0"
ISSUED FAB
ISSUED CONST

THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED

PLOT PLAN
MUSCATINE MUNICIPAL ELECTRIC PLT.

CLASS	AREA	JOB NO	DRAWING NO
		4118-03	FIG. 25

DRAWING NO.


13.2 KV SUBSTATION
TOWER
CONTROL ROOM
69 KV SUBSTATION
CANAL
SERVICE ROAD
DIKE
MAIN ROAD
TOWER
161 KV SUBSTATION
69 KV SUBSTATION
13 KV SUBSTATION
PARKING LOT
TOWER
GRATING
ON 69 KV LINES
SERVICE ROAD
DIKE
PROPERTY LINE
124'
UNITS 5 & 6
44'
TRACK HOPPER (REMOVED)
STACKS
SWITCH HOUSE
#5
#6
#7
#8
PRECIPITATORS
#5
#6
#7
#8
BOILERS
STACK
DUCT
BREAKER HOUSE (REMOVED)
MAIN BUILDING
STOCK ROOM
BOILER #9
PROPERTY LINE
RIVER CROSSING TOWER
SCREEN HOUSE #1
SCREEN HOUSE #2
BUILDING
MISSISSIPPI RIVER
FLOW
H
G
F
E
D

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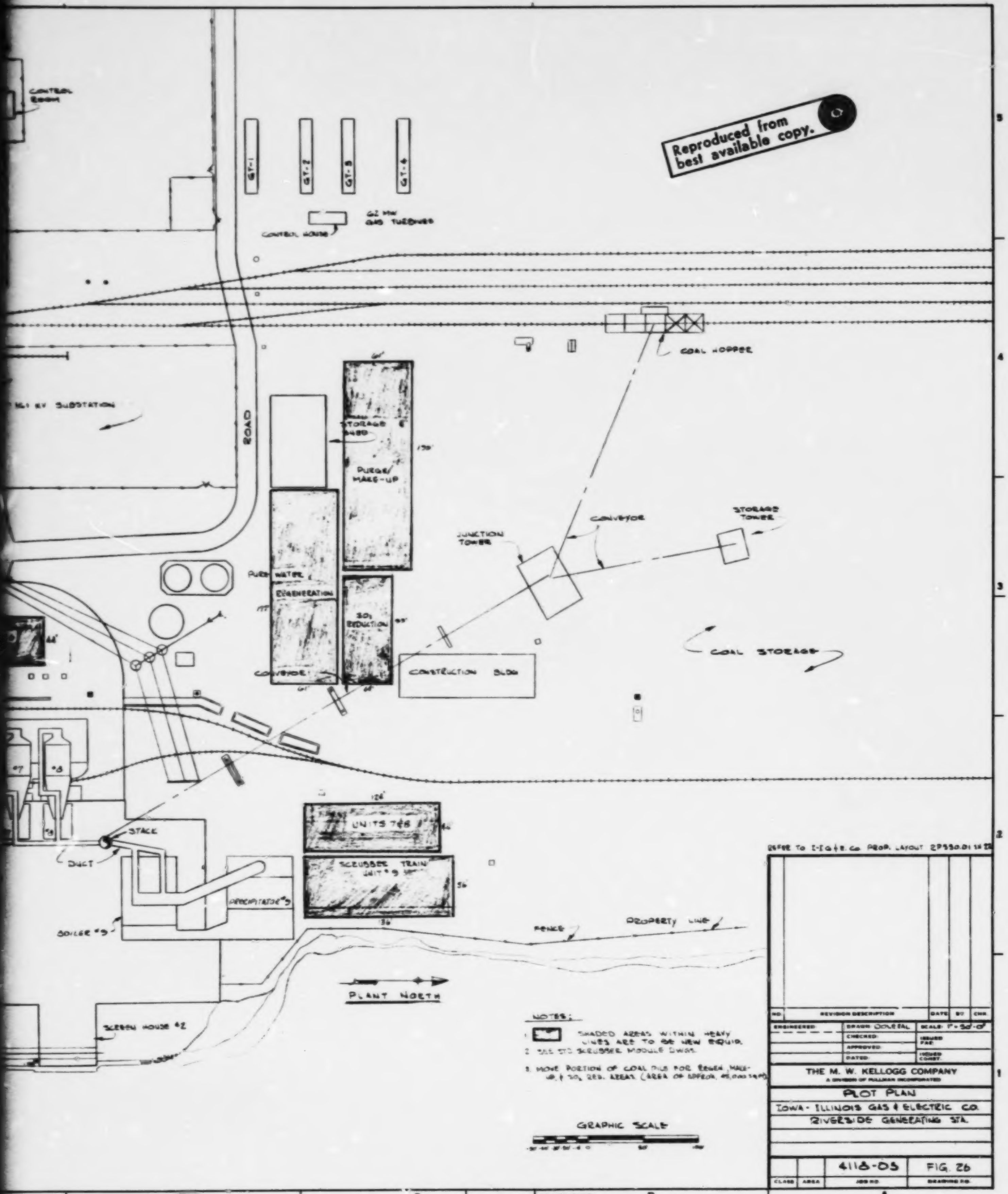

CONTROL ROOM
GT-1
GT-2
GT-3
GT-4
62 MW GAS TURBINES
CONTROL HOUSE
COAL HOPPER
161 KV SUBSTATION
ROAD
STORAGE 3480
PURGE/ MAKE-UP
130'
64'
PURE WATER REGENERATION
SO2 REDUCTION
CONVEYOR
CONSTRUCTION BLDG
JUNCTION TOWER
CONVEYOR
STORAGE TOWER
COAL STORAGE
44'
#7
#8
STACK
DUCT
UNITS 7&8
126'
SCRUBBER TRAIN UNIT #9
56'
136'
PRECIPITATOR #9
BOILER #9
FENCE
PROPERTY LINE
PLANT NORTH
SCREEN HOUSE #2
GRAPHIC SCALE
0
50'
100'
5
4
3
2
1
D
C
B
A

NOTES:

1. ▭ SHADED AREAS WITHIN HEAVY LINES ARE TO BE NEW EQUIP.
2. SEE STD SCRUBBER MODULE DWGS.
3. MOVE PORTION OF COAL PILE FOR REGEN, MAKE-UP, & SO2 RED. AREAS (AREA OF APPROX. 45,000 SQ FT)

REFER TO I-I G & E. Co. PROP. LAYOUT 2P330.01 SH 22

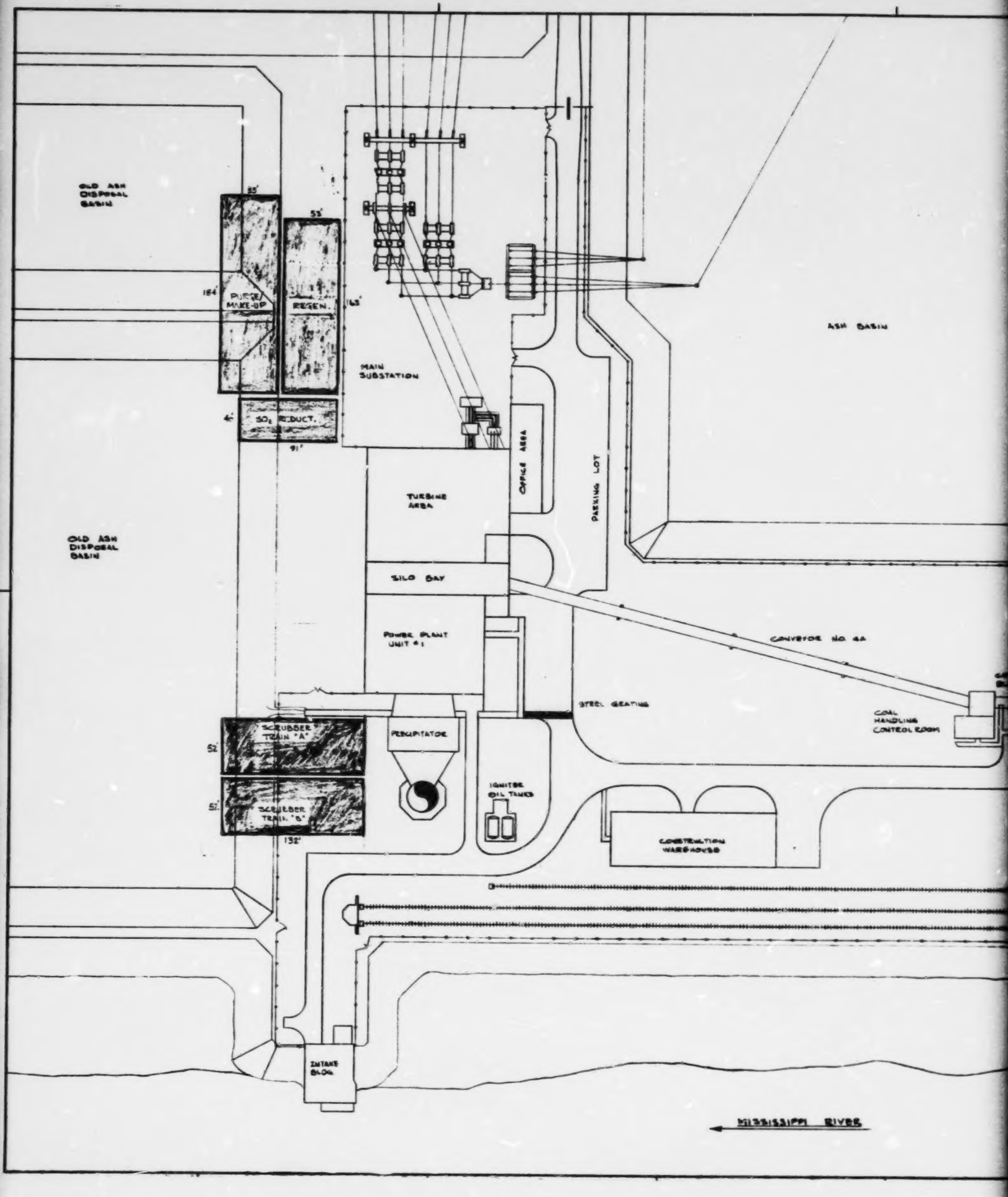
NO.	REVISION DESCRIPTION	DATE	BY	CHK

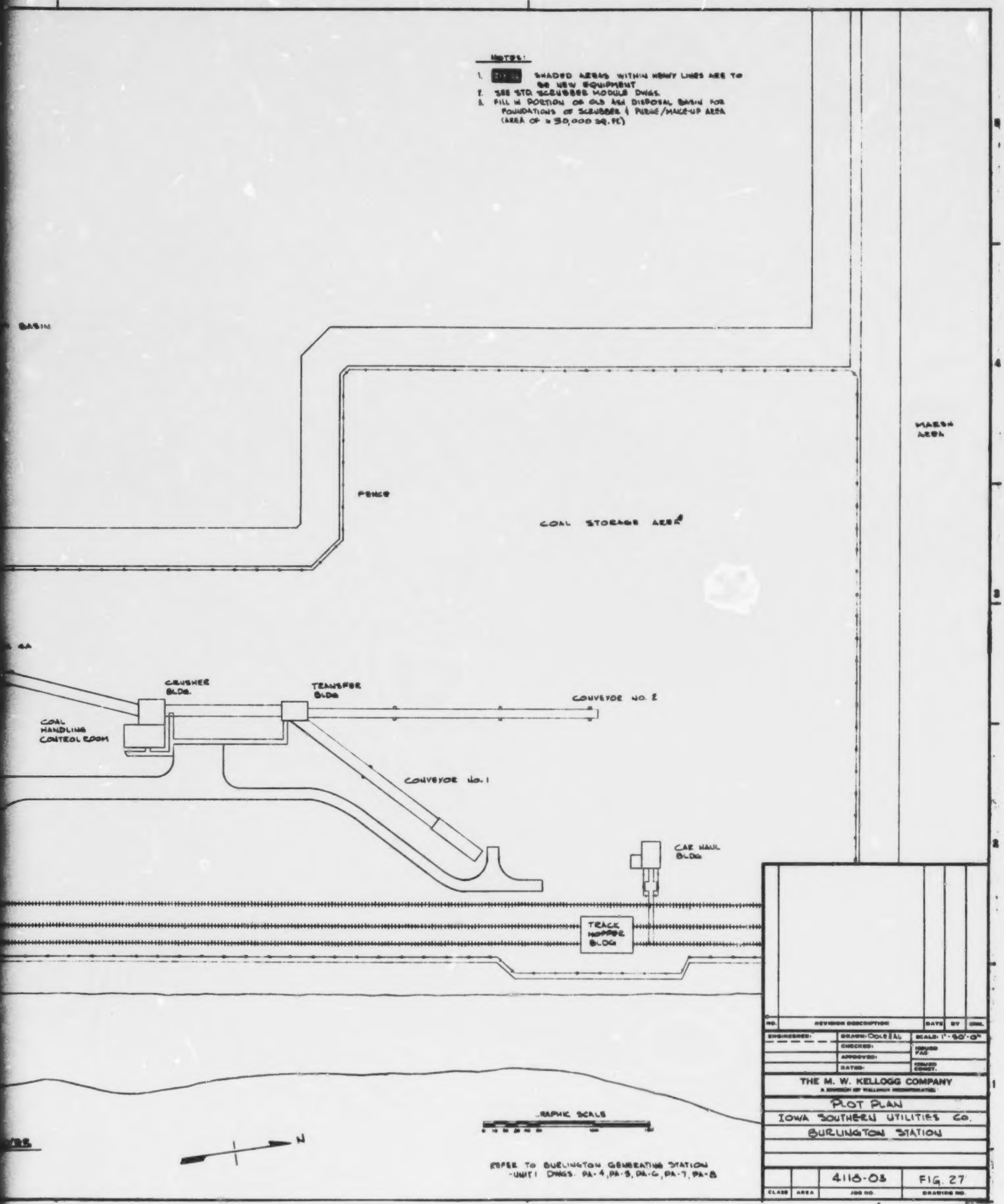
ENGINEERED:
DRAWN: DOLEZAL
CHECKED:
APPROVED:
DATED:
SCALE: 1" = 50'-0"
ISSUED FAB:
ISSUED CONST.:

THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED

PLOT PLAN
IOWA - ILLINOIS GAS & ELECTRIC CO.
RIVERSIDE GENERATING STA.

CLASS	AREA	JOB NO.	DRAWING NO.
		4118-03	FIG. 26


OLD ASH DISPOSAL BASIN
85'
53'
164'
PURGE/MAKE-UP
REGEN.
163'
MAIN SUBSTATION
46'
SO₂ REDUCT.
91'
ASH BASIN
TURBINE AREA
OFFICE AREA
PARKING LOT
OLD ASH DISPOSAL BASIN
SILO BAY
POWER PLANT UNIT #1
CONVEYOR NO. 4A
STEEL GRATING
COAL HANDLING CONTROL ROOM
SCRUBBER TRAIN "A"
52'
PRECIPITATOR
SCRUBBER TRAIN "B"
52'
132'
IGNITER OIL TANKS
CONSTRUCTION WAREHOUSE
INTAKE BLDG.
MISSISSIPPI RIVER


BASIN
FENCE
COAL STORAGE AREA
MARSH AREA
CRUSHER BLDG.
TRANSFER BLDG
CONVEYOR NO. 2
COAL HANDLING CONTROL ROOM
CONVEYOR NO. 1
CAR HAUL BLDG
TRACK HOPPER BLDG
GRAPHIC SCALE
N
5
4
3
2
1

NOTES:

1. ▨ SHADED AREAS WITHIN HEAVY LINES ARE TO BE NEW EQUIPMENT
2. SEE STD. SCRUBBER MODULE DWGS.
3. FILL IN PORTION OF OLD ASH DISPOSAL BASIN FOR FOUNDATIONS OF SCRUBBER & PURGE/MAKE-UP AREA (AREA OF ≈ 30,000 SQ. FT.)

REFER TO BURLINGTON GENERATING STATION -UNIT 1 DWGS. PA-4, PA-5, PA-6, PA-7, PA-8

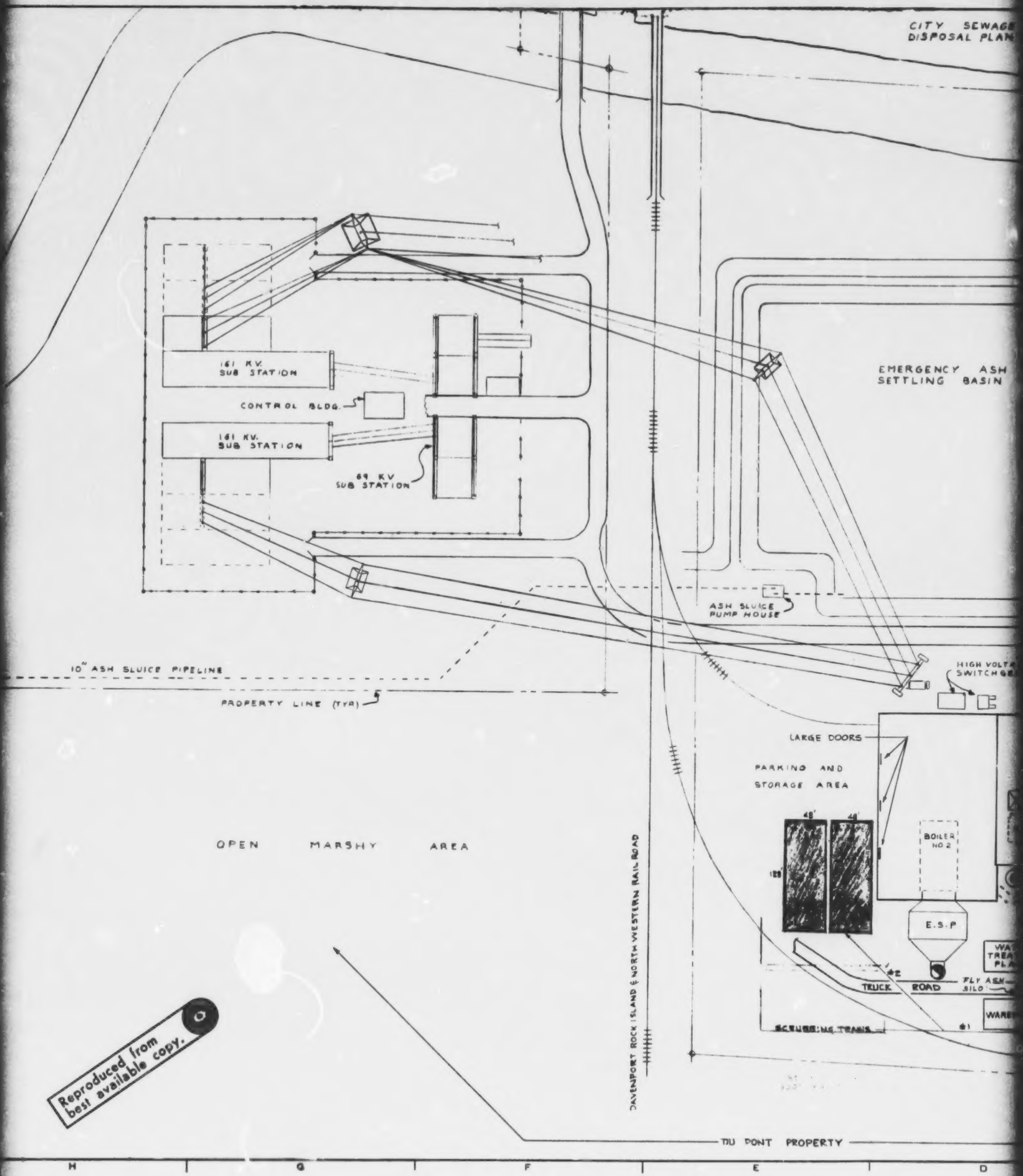
NO.	REVISION DESCRIPTION	DATE	BY	CHK.

ENGINEERED:
DRAWN: COLEMAN
CHECKED:
APPROVED:
DATED:
SCALE: 1" - 50'-0"
ISSUED FAB
ISSUED CONST.

THE M. W. KELLOGG COMPANY
[illegible]

PLOT PLAN
IOWA SOUTHERN UTILITIES CO.
BURLINGTON STATION

CLASS	AREA	JOB NO.	DRAWING NO.
		4116-03	FIG. 27


CITY SEWAGE
DISPOSAL PLAN
EMERGENCY ASH
SETTLING BASIN
161 KV.
SUB STATION
CONTROL BLDG.
161 KV.
SUB STATION
69 KV
SUB STATION
ASH SLUICE
PUMP HOUSE
10" ASH SLUICE PIPELINE
PROPERTY LINE (TYP)
HIGH VOLTA
SWITCHGE
LARGE DOORS
PARKING AND
STORAGE AREA
48'
48'
128'
BOILER
NO 2
E.S.P
WA
TREA
PLA
#2
TRUCK ROAD
FLY ASH
SILO
WARE
SCRUBBING TRAIN
#1
OPEN MARSHY AREA
DAVENPORT ROCK ISLAND & NORTH WESTERN RAIL ROAD
DU PONT PROPERTY
H
G
F
E
D

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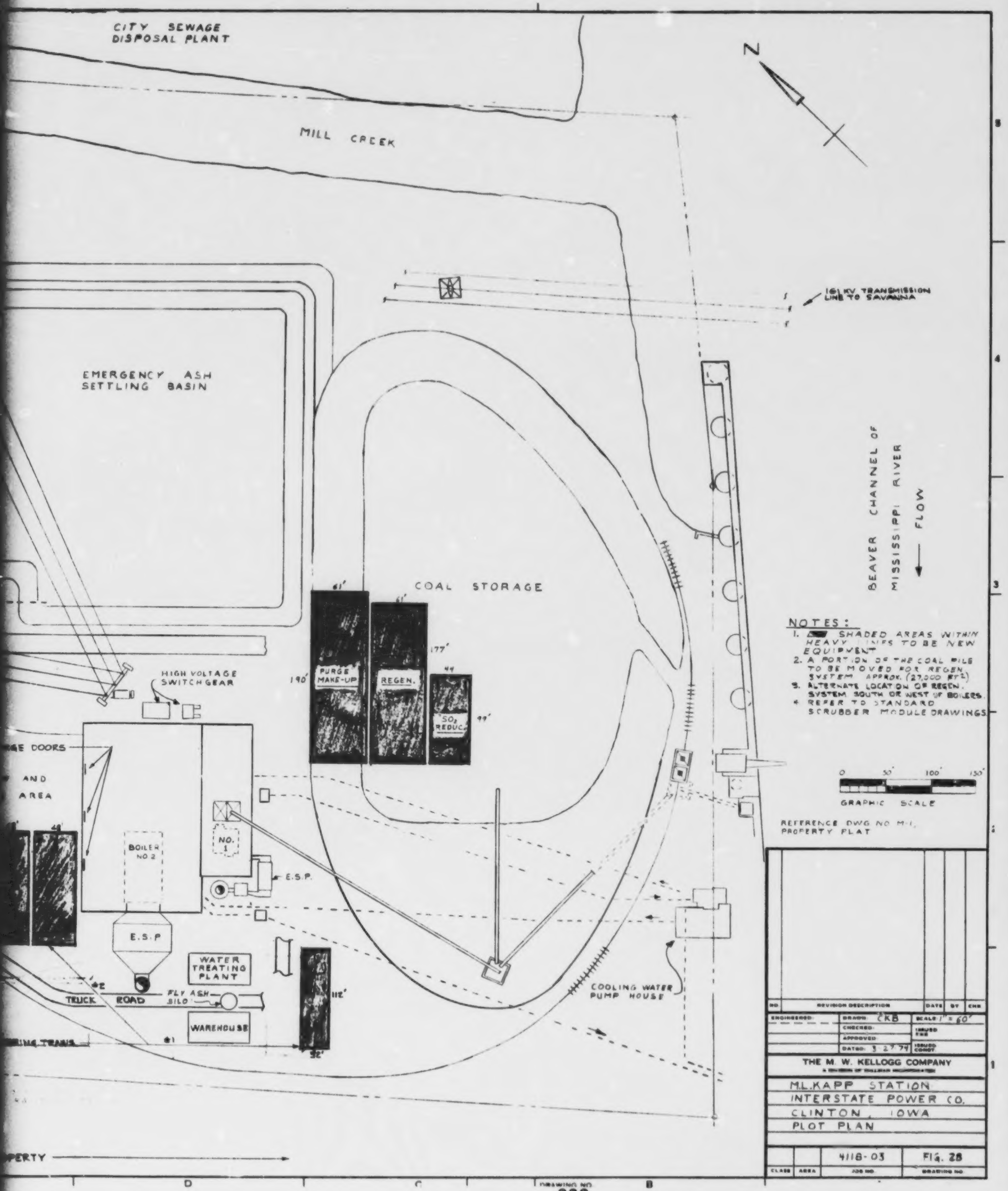

CITY SEWAGE DISPOSAL PLANT
MILL CREEK
N
161 KV TRANSMISSION LINE TO SAVANNA
EMERGENCY ASH SETTLING BASIN
COAL STORAGE
BEAVER CHANNEL OF MISSISSIPPI RIVER
FLOW
61'
61'
177'
44
190'
PURGE MAKE-UP
REGEN.
SO_2 REDUC.
99'
HIGH VOLTAGE SWITCH GEAR
GE DOORS
AND
AREA
41'
BOILER NO 2
NO. 1
E.S.P.
E.S.P
WATER TREATING PLANT
#2
TRUCK ROAD
FLY ASH SILO
WAREHOUSE
#1
RING TRAIN
112'
32'
COOLING WATER PUMP HOUSE
PERTY
0
50'
100'
150'
GRAPHIC SCALE
D
C
B
5
4
3
2
1

NOTES:

1. ▨ SHADED AREAS WITHIN HEAVY LINES TO BE NEW EQUIPMENT
2. A PORTION OF THE COAL PILE TO BE MOVED FOR REGEN. SYSTEM APPROX. (27,000 FT^2)
3. ALTERNATE LOCATION OF REGEN. SYSTEM SOUTH OR WEST OF BOILERS.
4. REFER TO STANDARD SCRUBBER MODULE DRAWINGS.

REFERENCE DWG NO M-1, PROPERTY PLAT

NO	REVISION DESCRIPTION	DATE	BY	CHK

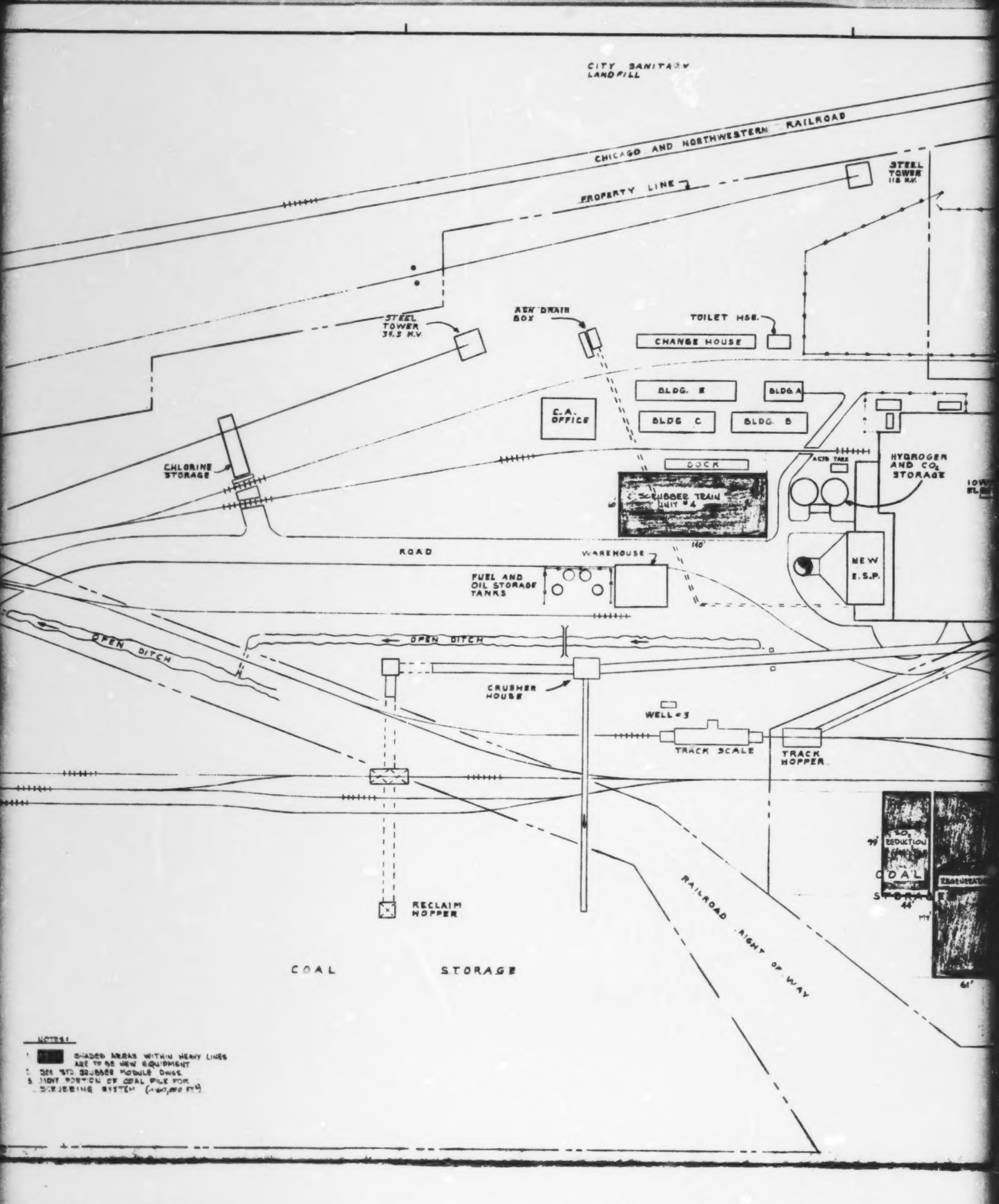
ENGINEERED:
DRAWN: CKB
CHECKED:
APPROVED:
DATED: 3-27-74
SCALE: 1" = 60'
ISSUED FOR
ISSUED CONST.

THE M. W. KELLOGG COMPANY

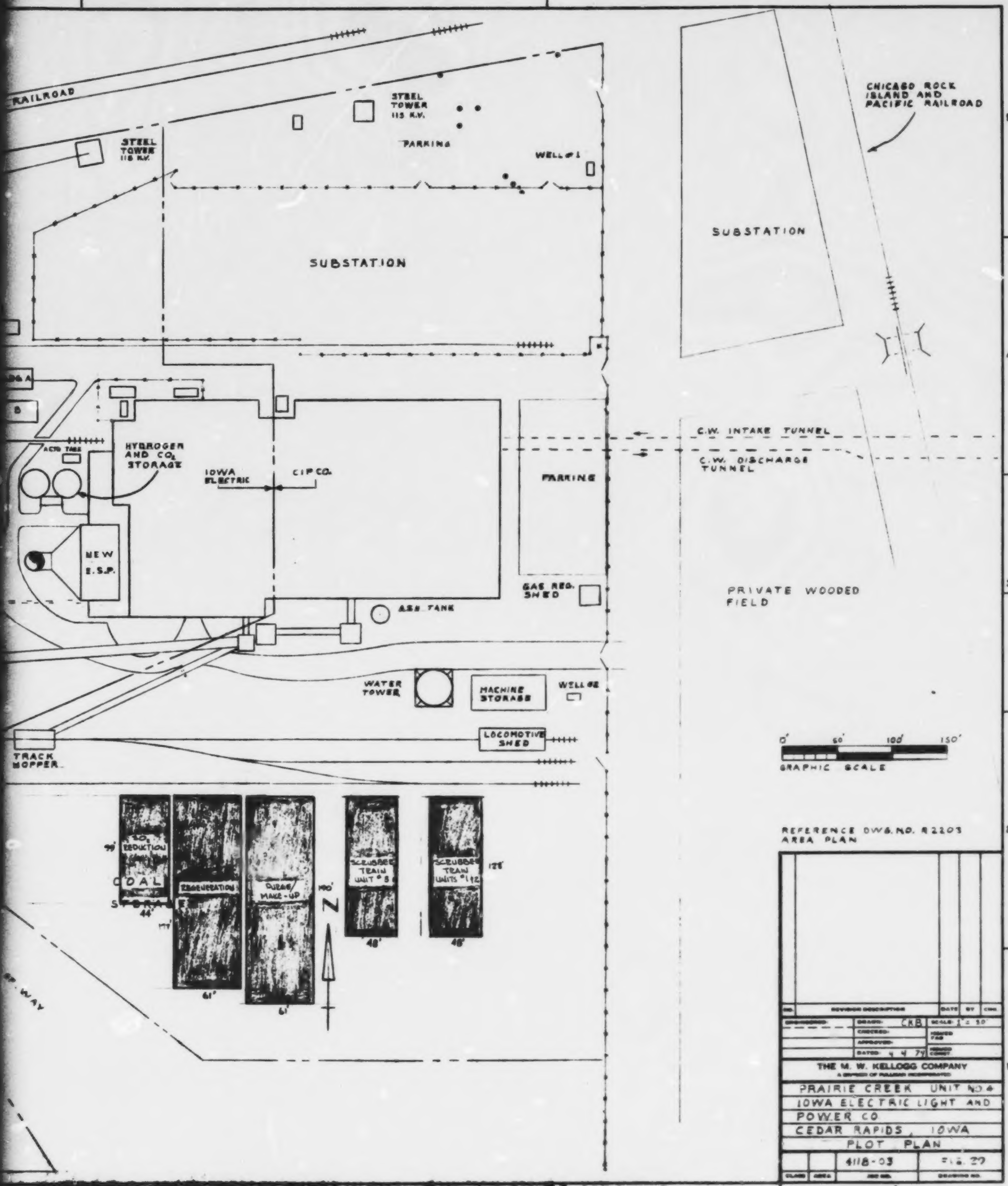
M.L.KAPP STATION
INTERSTATE POWER CO.
CLINTON, IOWA
PLOT PLAN

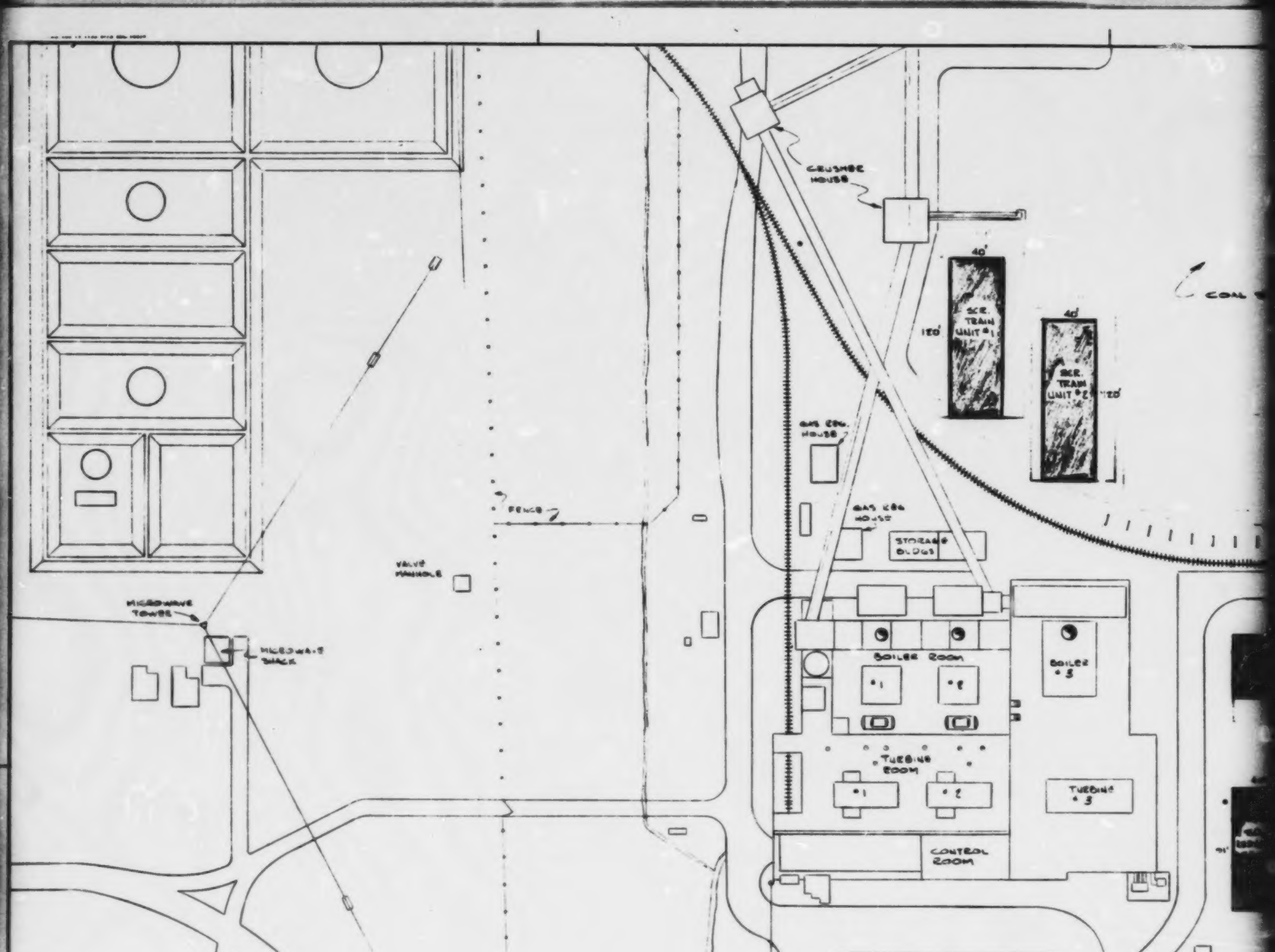
CLASS	AREA	JOB NO.	DRAWING NO.
		4118-03	FIG. 28

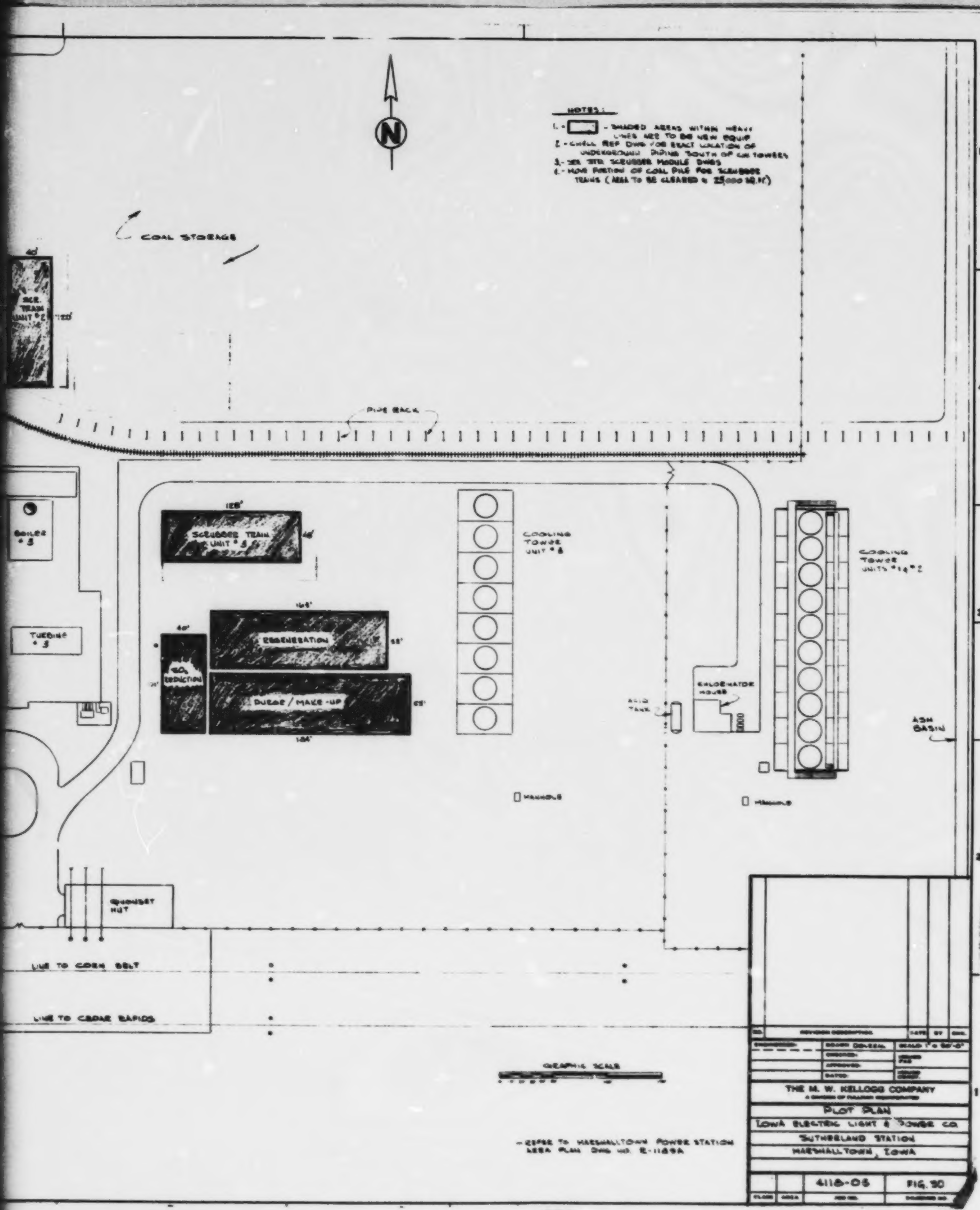
DRAWING NO.


CITY SANITARY LANDFILL
CHICAGO AND NORTHWESTERN RAILROAD
PROPERTY LINE
STEEL TOWER 115 K.V.
STEEL TOWER 34.5 K.V.
ASH DRAIN BOX
TOILET HSE.
CHANGE HOUSE
BLDG. E
BLDG. A
C.A. OFFICE
BLDG. C
BLDG. B
CHLORINE STORAGE
DOCK
ACID TANK
HYDROGEN AND CO2 STORAGE
IOWA
EL.
SCRUBBER TRAIN UNIT #4
60'
140'
ROAD
WAREHOUSE
FUEL AND OIL STORAGE TANKS
NEW E.S.P.
OPEN DITCH
OPEN DITCH
CRUSHER HOUSE
WELL #3
TRACK SCALE
TRACK HOPPER
SO2 REDUCTION
REGENERATION
99'
44'
147'
61'
RECLAIM HOPPER
RAILROAD RIGHT OF WAY
COAL STORAGE
COAL STORAGE

NOTES:
1. ▇ SHADED AREAS WITHIN HEAVY LINES ARE TO BE NEW EQUIPMENT
2. SEE STD SCRUBBER MODULE DWGS.
3. MOVE PORTION OF COAL PILE FOR SCRUBBING SYSTEM (±60,000 FT²)

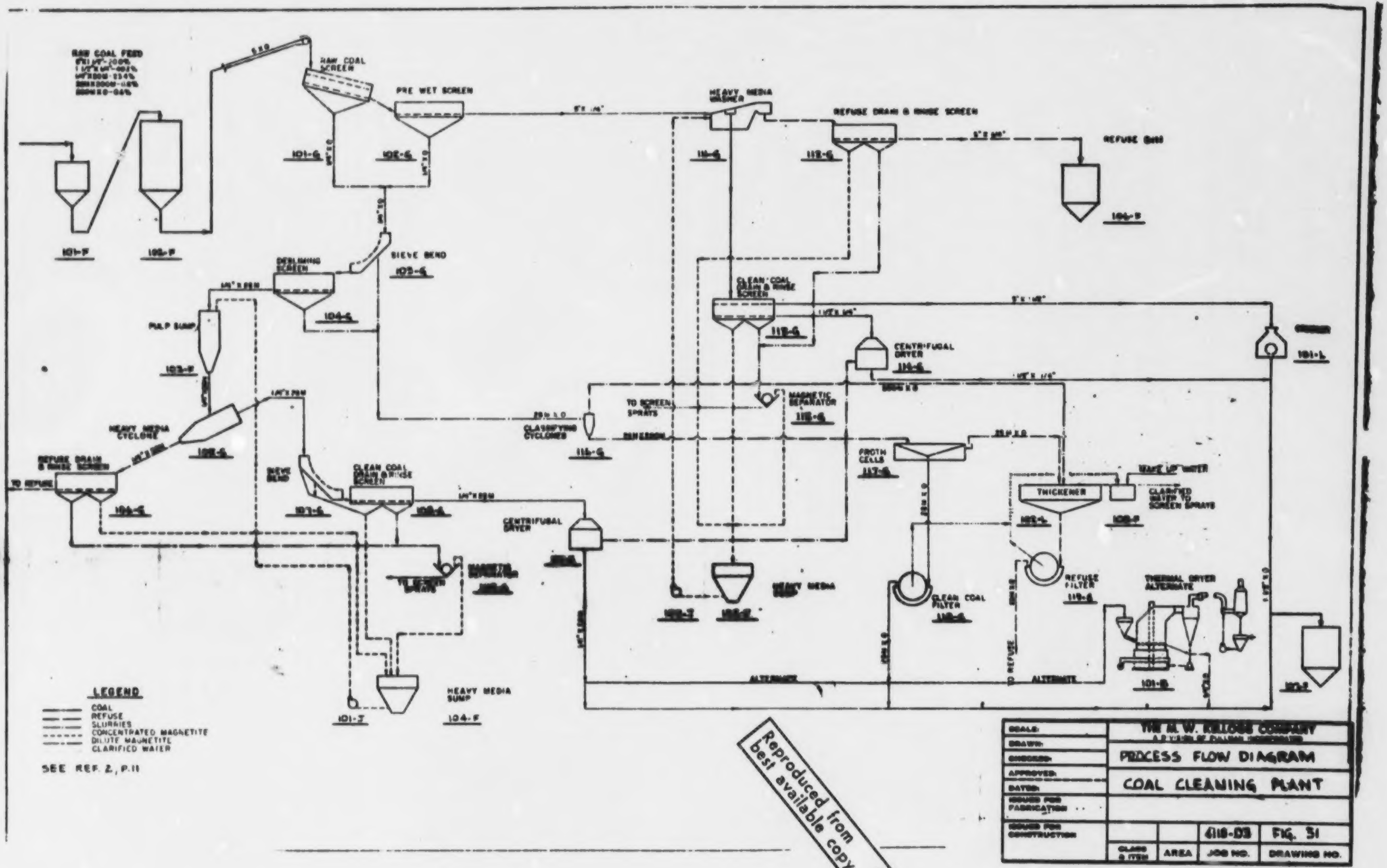

RAILROAD
STEEL TOWER 115 K.V.
STEEL TOWER 115 K.V.
PARKING
WELL #1
CHICAGO ROCK ISLAND AND PACIFIC RAILROAD
SUBSTATION
SUBSTATION
BLDG A
B
ACID TANK
HYDROGEN AND CO2 STORAGE
IOWA ELECTRIC
CIPCO.
PARKING
NEW E.S.P.
C.W. INTAKE TUNNEL
C.W. DISCHARGE TUNNEL
GAS REG. SHED
ASH TANK
PRIVATE WOODED FIELD
WATER TOWER
MACHINE STORAGE
WELL #2
LOCOMOTIVE SHED
TRACK HOPPER
0' 50' 100' 150'
GRAPHIC SCALE
SO2 REDUCTION
COAL STORAGE
99'
44'
REGENERATION
177'
61'
PURGE/ MAKE-UP
190'
61'
N
SCRUBBER TRAIN UNIT #3
48'
SCRUBBER TRAIN UNITS #1 & 2
128'
48'
R.R. WAY
REFERENCE DWG. NO. R2203 AREA PLAN
NO. REVISION DESCRIPTION DATE BY CHK.
DRAWN: CKB
SCALE: 1" = 50'
DATED: 4 4 79
THE M. W. KELLOGG COMPANY
PRAIRIE CREEK UNIT NO. 4
IOWA ELECTRIC LIGHT AND POWER CO.
CEDAR RAPIDS, IOWA
PLOT PLAN
4118-03
FIG. 29
1
2
3
4
5
A


CRUSHER HOUSE
40'
120'
SCR. TRAIN UNIT #1
40'
SCR. TRAIN UNIT #2
120'
COAL
GAS COM. HOUSE
GAS COM. HOUSE
STORAGE BLDGS
FENCE
VALVE MANHOLE
MICROWAVE TOWER
MICROWAVE SHACK
BOILER ROOM
#1
#2
BOILER #3
TURBINE ROOM
#1
#2
TURBINE #3
CONTROL ROOM
PARKING AREA
FARM HOUSE
QUONSET HUT
LINE TO CORN BELT
LINE TO CEDAR RAPIDS
115 KV SUBSTATION


N
NOTES:
1. - SHADED AREAS WITHIN HEAVY LINES ARE TO BE NEW EQUIP
2. - CHECK REF DWG FOR EXACT LOCATION OF UNDERGROUND PIPING SOUTH OF CW TOWERS
3. - SEE STD SCRUBBER MODULE DWGS
4. - MOVE PORTION OF COAL PILE FOR SCRUBBER TRAINS (AREA TO BE CLEARED ≈ 25,000 SQ.FT)
COAL STORAGE
40'
SCR. TRAIN UNIT #2
120'
PIPE RACK
128'
SCRUBBER TRAIN UNIT #3
40'
BOILER #3
TURBINE #3
165'
REGENERATION
55'
40'
SO2 REDUCTION
70'
PURGE / MAKE-UP
65'
184'
COOLING TOWER UNIT #3
COOLING TOWER UNITS #1 & #2
ACID TANK
CHLORINATOR HOUSE
ASH BASIN
MANHOLE
MANHOLE
QUONSET HUT
LINE TO CORN BELT
LINE TO CEDAR RAPIDS
GRAPHIC SCALE
REFER TO MARSHALLTOWN POWER STATION AREA PLAN DWG NO. E-1189A
5
4
3
2
1
SCALE 1" = 50'-0"
THE M. W. KELLOGG COMPANY
PLOT PLAN
IOWA ELECTRIC LIGHT & POWER CO.
SUTHERLAND STATION
MARSHALLTOWN, IOWA
4118-05
FIG. 30

APPENDIX D

COAL CLEANING SYSTEM


RAW COAL FEED
101-F
102-F
RAW COAL SCREEN
101-G
PRE WET SCREEN
102-G
SIEVE BEND
103-G
DESLIMING SCREEN
104-G
PULP SUMP
103-F
HEAVY MEDIA CYCLONE
105-G
REFUSE DRAIN & RINSE SCREEN
106-G
TO REFUSE
SIEVE BEND
107-G
CLEAN COAL DRAIN & RINSE SCREEN
108-G
CENTRIFUGAL DRYER
MAGNETIC SEPARATOR
TO SCREEN SPRAYS
HEAVY MEDIA SUMP
101-J
104-F
CLASSIFYING CYCLONES
116-G
HEAVY MEDIA WASHER
111-G
REFUSE DRAIN & RINSE SCREEN
112-G
REFUSE BIN
106-F
CLEAN COAL DRAIN & RINSE SCREEN
113-G
CENTRIFUGAL DRYER
114-G
MAGNETIC SEPARATOR
115-G
HEAVY MEDIA SUMP
FROTH CELLS
117-G
THICKENER
MAKE UP WATER
CLARIFIED WATER TO SCREEN SPRAYS
108-F
CLEAN COAL FILTER
118-G
REFUSE FILTER
119-G
TO REFUSE
THERMAL DRYER ALTERNATE
101-B
ALTERNATE
ALTERNATE
101-L
LEGEND
COAL
REFUSE
SLURRIES
CONCENTRATED MAGNETITE
DILUTE MAGNETITE
CLARIFIED WATER
SEE REF. 2, P.11
SCALE:
DRAWN:
CHECKED:
APPROVED:
DATED:
ISSUED FOR FABRICATION
ISSUED FOR CONSTRUCTION
THE M. W. KELLOGG COMPANY
PROCESS FLOW DIAGRAM
COAL CLEANING PLANT
4118-03
FIG. 31
CLASS & ITEM
AREA
JOB NO.
DRAWING NO.

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ENG PROJ 6 8-70

Table 27
EQUIPMENT LIST (Incomplete - not all pumps, conveyors, sumps, etc. shown)

JOB/EST. NO. 4118-03

CLIENT: EPA - Iowa Utilities Study

LOCATION: Iowa

TYPE UNIT: Coal Cleaning Plant

CLASS B, F, G

PAGE NO.: 1 OF 2

ITEM NO.	DESCRIPTION EQUIPMENT TYPE: B - Furnaces, Fired Heaters, & Stacks	ITEM CHANGED (✓)	ISSUE NO.
101-B	Thermal Dryer (Alternate)		
	F - Drums and Tanks		
101-F	Raw Coal Receiving Bin		
102-F	Raw Coal Silo		
103-F	Pulp Sump		
104-F	Heavy Media Sump (Fine Coal Treatment)		
105-F	Heavy Media Sump (Coarse Coal Treatment)		
106-F	Refuse Bin		
107-F	Clean Coal Silo		
108-F	Water Tank		
	G - Separators		
101-G	Raw Coal Screen		
102-G	Pre-Wet Screen		
103-G	Sieve Bend Screen		
104-G	Desliming Screen		
105-G	Heavy Media Cyclone (Fines)		
106-G	Refuse Drain and Rinse Screen		
107-G	Second Sieve Bend Screen		
108-G	Clean Coal Drain and Rinse Screen (Fines)		
109-G	Magnetic Separator (Fines)		
110-G	Centrifugal Dryer		
111-G	Heavy Media Washer		
112-G	Refuse Drain and Rinse Screen (Coarse)		
113-G	Clean Coal Drain and Rinse Screen (Coarse)		
114-G	Centrifugal Dryer (Coarse)		
115-G	Magnetic Separator (Coarse)		
116-G	Classifying Cyclones		
117-G	Froth Cells		
118-G	Clean Coal Filter		

CHECKS IN FAR RIGHT HAND COLUMN INDICATE ITEMS CHANGED IN LATEST ISSUE.

STANDARD DISTRIBUTION (ENTIRE EQUIPMENT LIST)						ADDITIONAL DISTRIB. THIS SHEET ONLY	
DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.		ATTENTION OF:	DIV. OR SECT.	ATTENTION OF:
DESIGN	PIPING DESIGN		CIVIL-MECH	STANDARDS & SPECS.		PURCHASING AGENT	
	PLANT LAYOUT			CIVIL ENG.			
	MATERIAL CONTROL			FURNACE-EXCH. DIV.			
	PIPE SUPPORTS			MECHANICAL ENG. DIV.			
	PIPING INSTRUMENT		ESTIMATING SERVICES				
	LIGHT & POWER		SCHEDULING SERVICES				
	ELECTRICAL INSTRUMENT		CONST.	HOME OFFICE			
SYSTEMS	SYSTEMS ENG.			FIELD			
	INSTRUMENT ENG.		COST SERVICES				
	EQUIPMENT ENG.		PROCESS MGR.				

ISSUE NO.	1	2	3	4	5	6	7	8	9	10	11	12
DATE												

ENG PROJ 6 9-70

EQUIPMENT LIST

JOB/EST. NO.

CLIENT:
LOCATION:
TYPE UNIT:

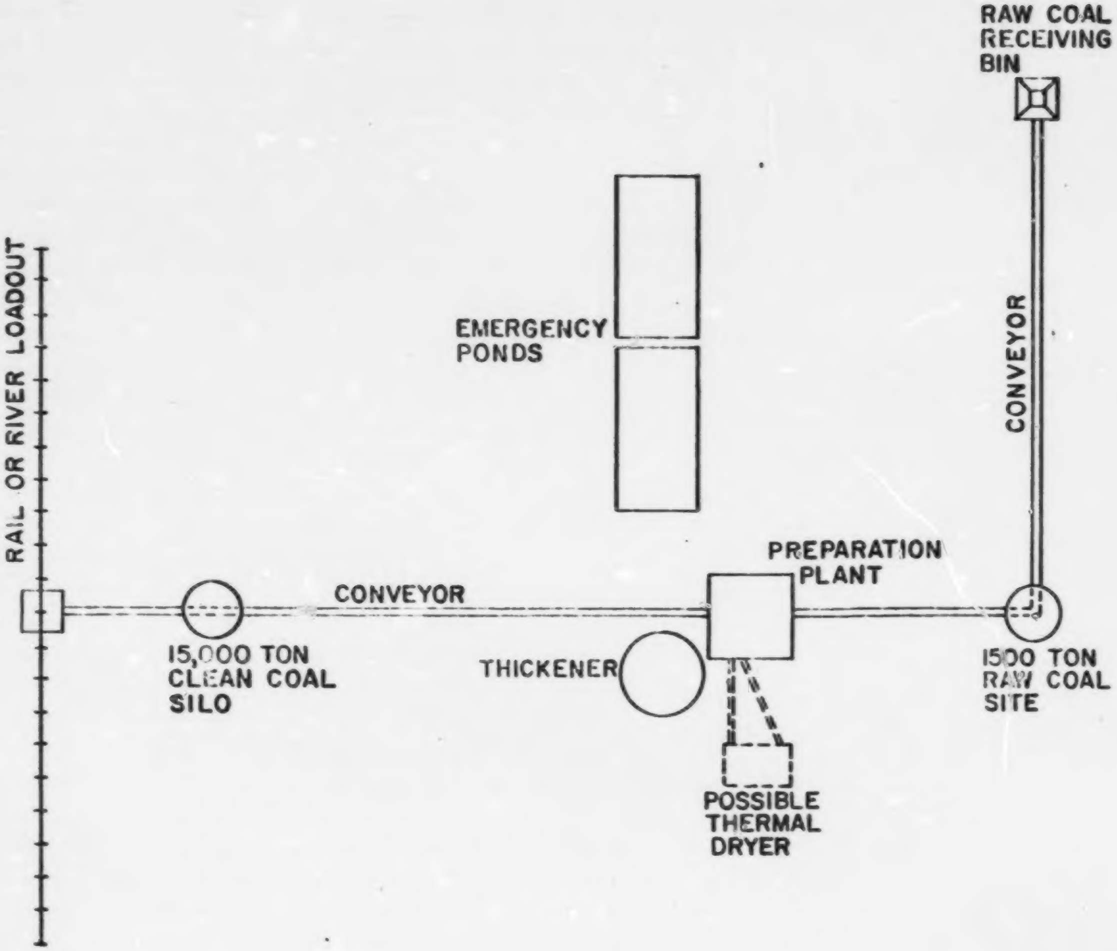
CLASS G, J, K, L
PAGE NO.: 2 OF 2

ITEM NO.	DESCRIPTION EQUIPMENT TYPE: G - Separators (Cont.)	ITEM CHANGED (✓)	ISSUE NO.
119-G	Refuse Filter		
	J - Pumps, Compressors, Drivers		
101-J	Heavy Media Pumps (Fines)		
102-J	Heavy Media Pumps (Coarse)		
	K - Buildings		
101-K	Preparation Plant Building		
	L - Special Equipment		
101-L	Coal Crusher		
102-L	Thickener		

CHECKS IN FAR RIGHT HAND COLUMN INDICATE ITEMS CHANGED IN LATEST ISSUE.

STANDARD DISTRIBUTION (ENTIRE EQUIPMENT LIST)				ADDITIONAL DISTRIB. THIS SHEET ONLY	
DIV. OR SECT.	ATTENTION OF:	DIV. OR SECT.	ATTENTION OF:	DIV. OR SECT.	ATTENTION OF:
DESIGN: PIPING DESIGN		CIVIL-MECH: STANDARDS & SPECS.		PURCHASING AGENT	
PLANT LAYOUT		CIVIL ENG.			
MATERIAL CONTROL		FURNACE-EXCH. DIV.			
PIPE SUPPORTS		MECHANICAL ENG. DIV.			
PIPING INSTRUMENT		ESTIMATING SERVICES			
LIGHT & POWER		SCHEDULING SERVICES			
ELECTRICAL INSTRUMENT		CONST.: HOME OFFICE			
SYSTEMS: SYSTEMS ENG.		FIELD			
INSTRUMENT ENG.		COST SERVICES			
EQUIPMENT ENG.		PROCESS MGR.			

ISSUE NO.	1	2	3	4	5	6	7	8	9	10	11	12
DATE												


RAW COAL
RECEIVING
BIN
CONVEYOR
EMERGENCY
PONDS
RAIL OR RIVER LOADOUT
PREPARATION
PLANT
CONVEYOR
15,000 TON
CLEAN COAL
SILO
THICKENER
1500 TON
RAW COAL
SITE
POSSIBLE
THERMAL
DRYER

SKETCH OF TYPICAL SITE LAYOUT
PREPARATION FACILITIES

THE M.W. KELLOGG COMPANY
HOUSTON, TEXAS

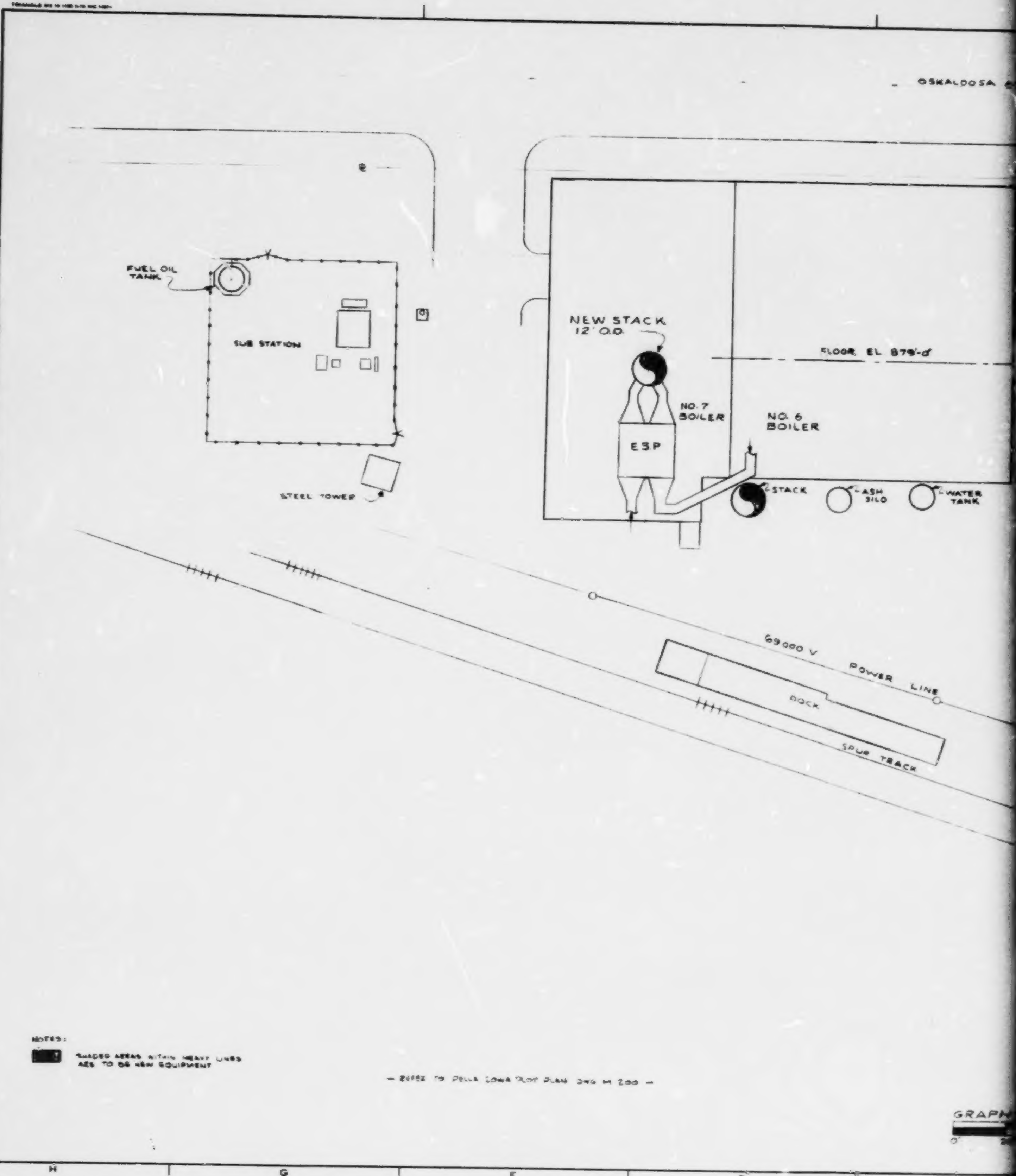
GATES ENGINEERING COMPANY
CONSULTANTS
DENVER BECKLEY CHICAGO

FIG. 32

SCALE: 1"=200' DATE: 5/7/74

APPENDIX E

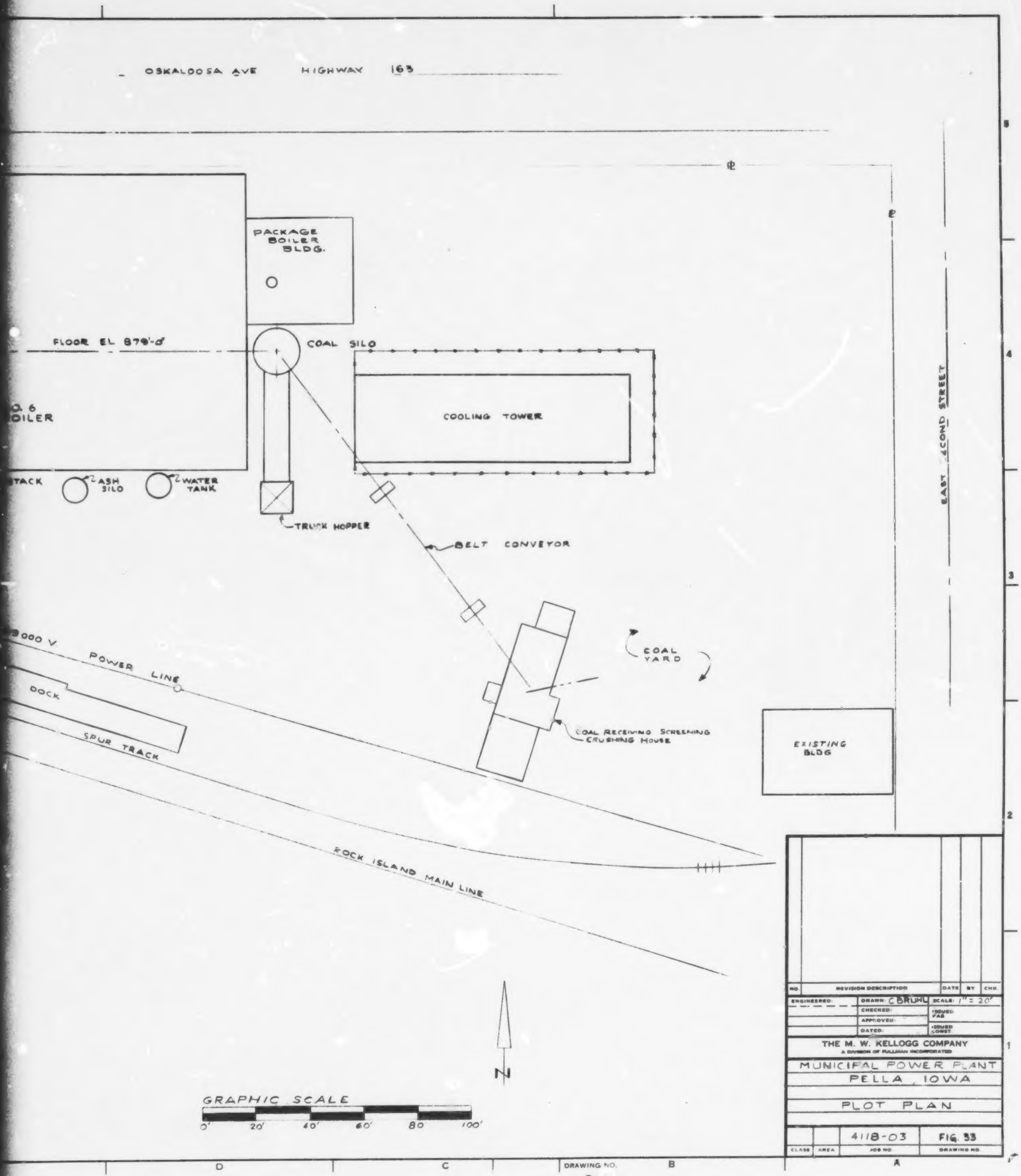
PLOT PLANS OF OTHER POWER PLANTS


OSKALOOSA
FUEL OIL TANK
SUB STATION
STEEL TOWER
NEW STACK 12' O.D.
FLOOR EL 879'-0"
NO. 7 BOILER
NO. 6 BOILER
ESP
℄ STACK
℄ ASH SILO
℄ WATER TANK
69 000 V POWER LINE
DOCK
SPUR TRACK
GRAPH
0'
D
H
G
F
E
D

NOTES:

▇ SHADED AREAS WITHIN HEAVY LINES ARE TO BE NEW EQUIPMENT

— REFER TO PELLA IOWA PLOT PLAN DWG M 200 —


OSKALOOSA AVE HIGHWAY 163
℄
℄
PACKAGE BOILER BLDG.
FLOOR EL 879'-0"
COAL SILO
COOLING TOWER
O. 6
OILER
STACK
2 ASH SILO
2 WATER TANK
TRUCK HOPPER
BELT CONVEYOR
EAST SECOND STREET
000 V. POWER LINE
DOCK
SPUR TRACK
COAL YARD
COAL RECEIVING SCREENING CRUSHING HOUSE
EXISTING BLDG
ROCK ISLAND MAIN LINE
N
GRAPHIC SCALE
0' 20' 40' 60' 80' 100'
D
C
B
A
1
2
3
4
5
DRAWING NO.

NO.	REVISION DESCRIPTION	DATE	BY	CHK

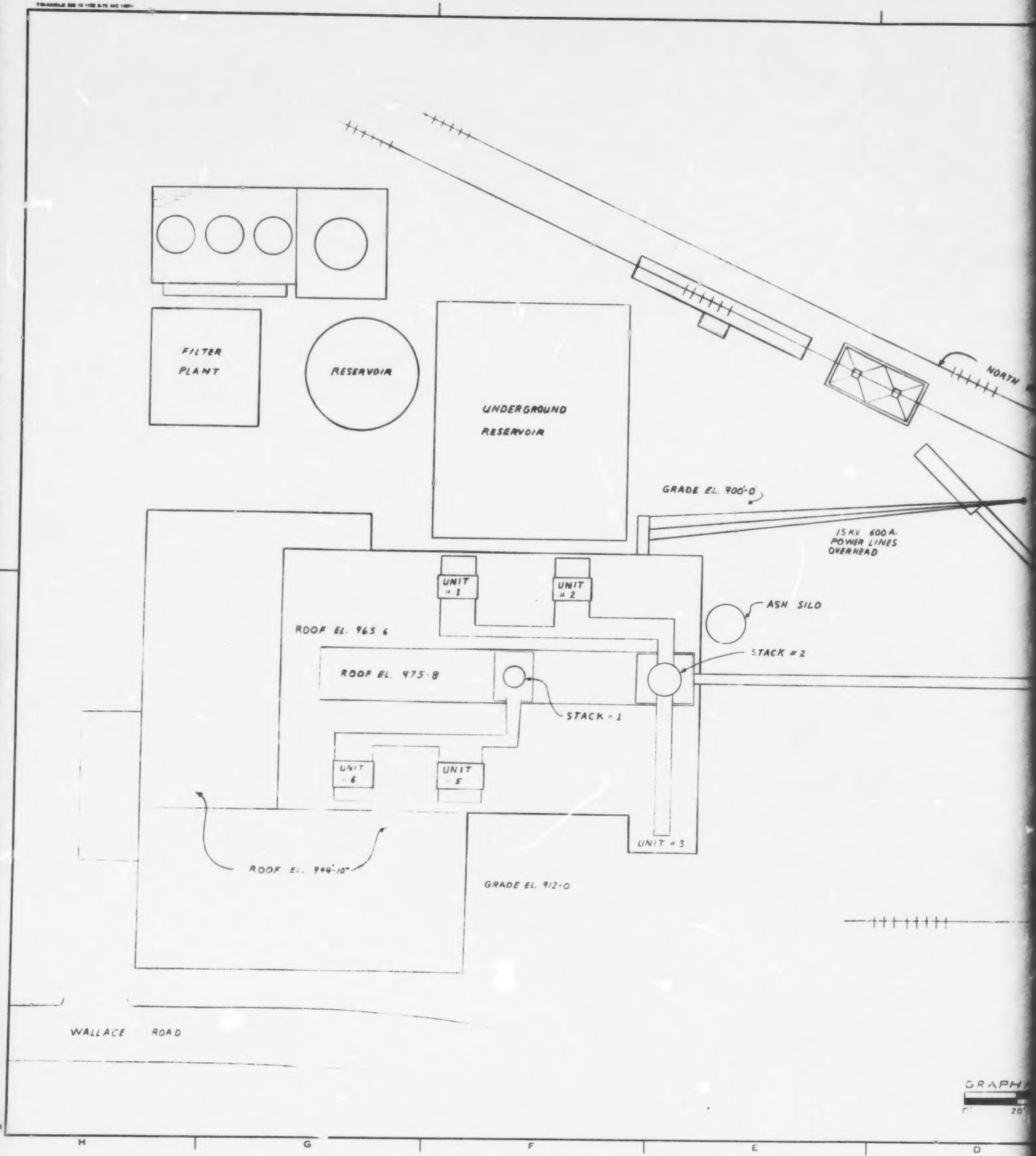
ENGINEERED:	DRAWN: C BRUHL	SCALE: 1" = 20'
	CHECKED:	ISSUED FAB
	APPROVED:	
	DATED:	ISSUED CONST

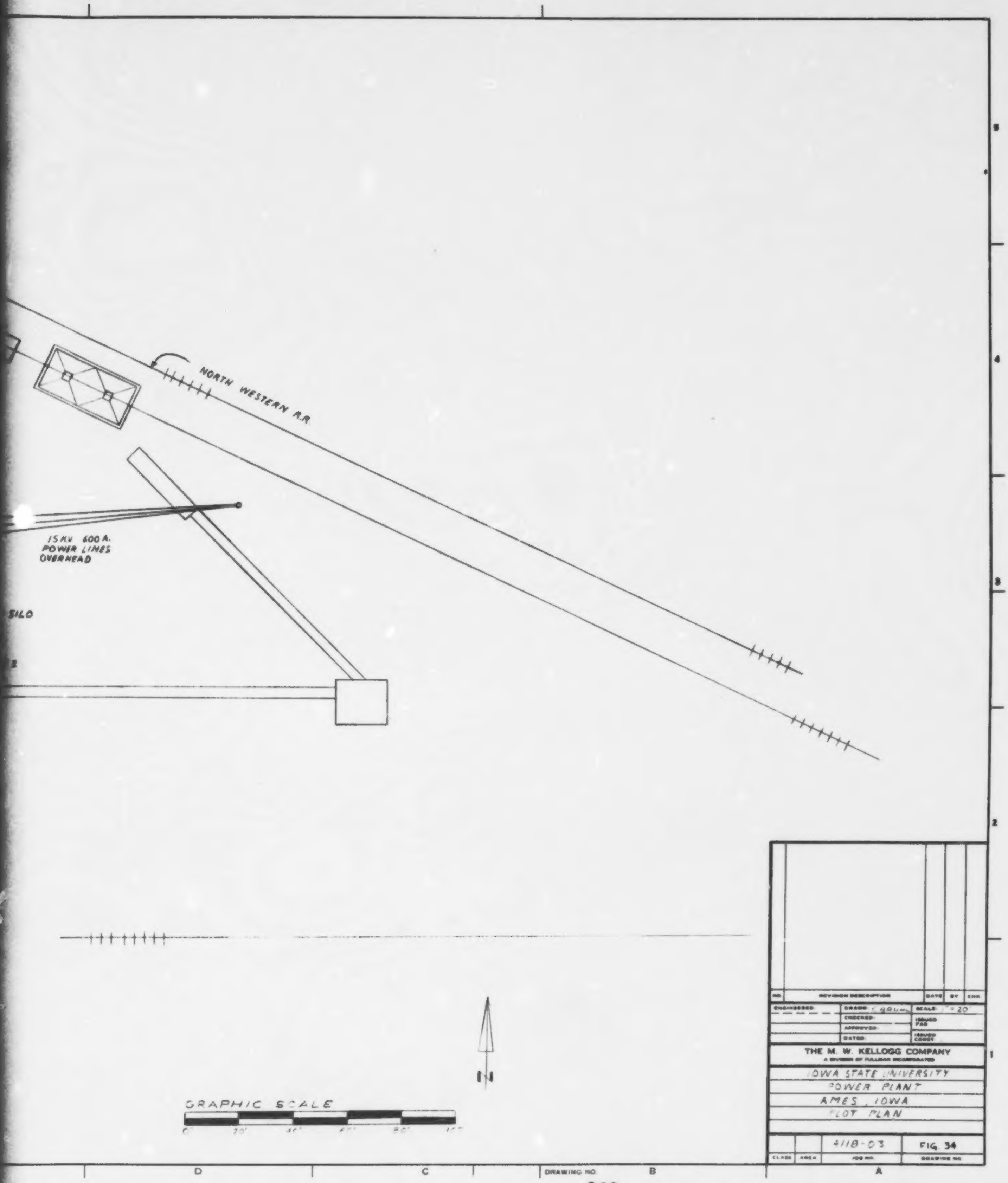
THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED

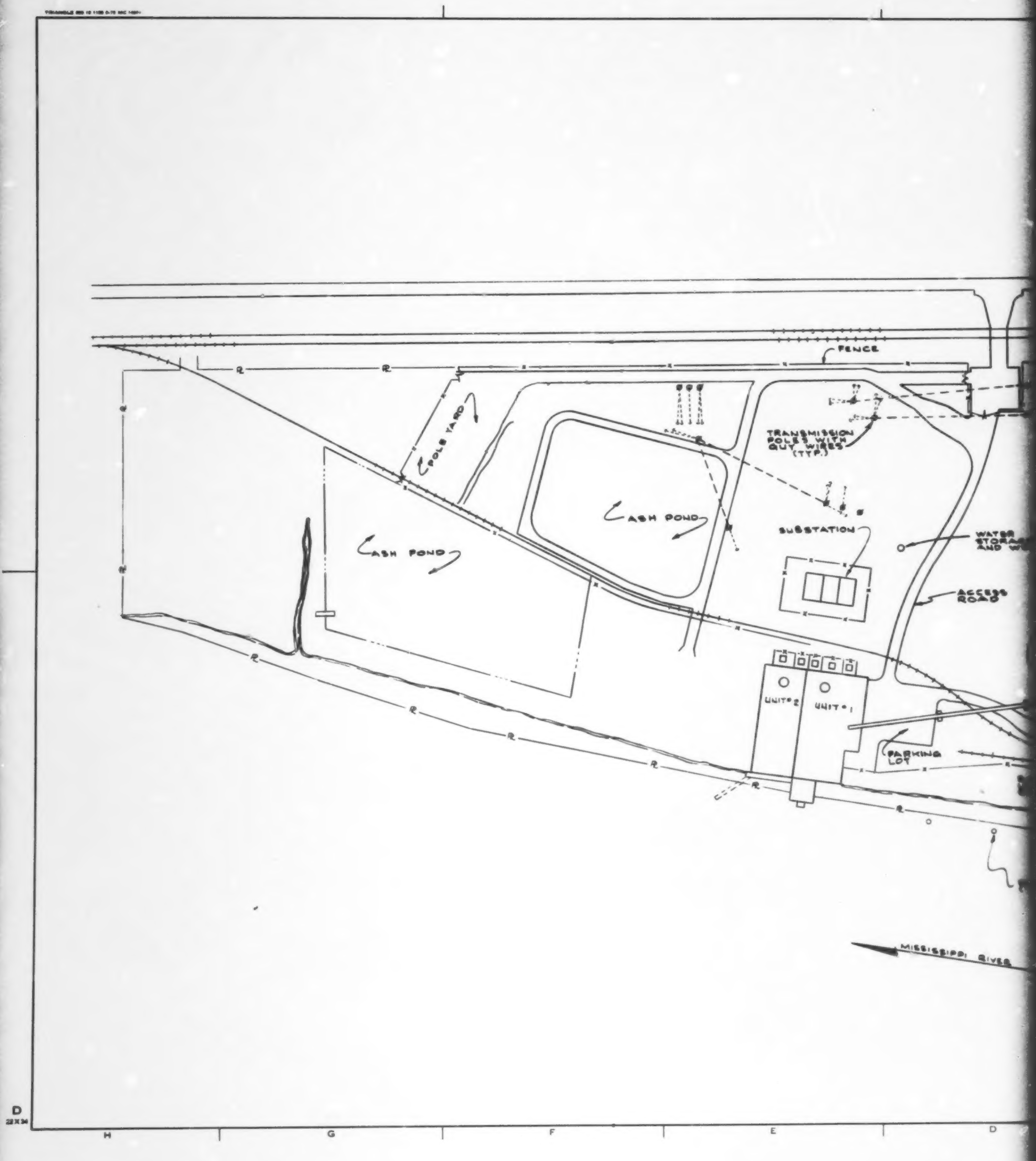
MUNICIPAL POWER PLANT
PELLA, IOWA

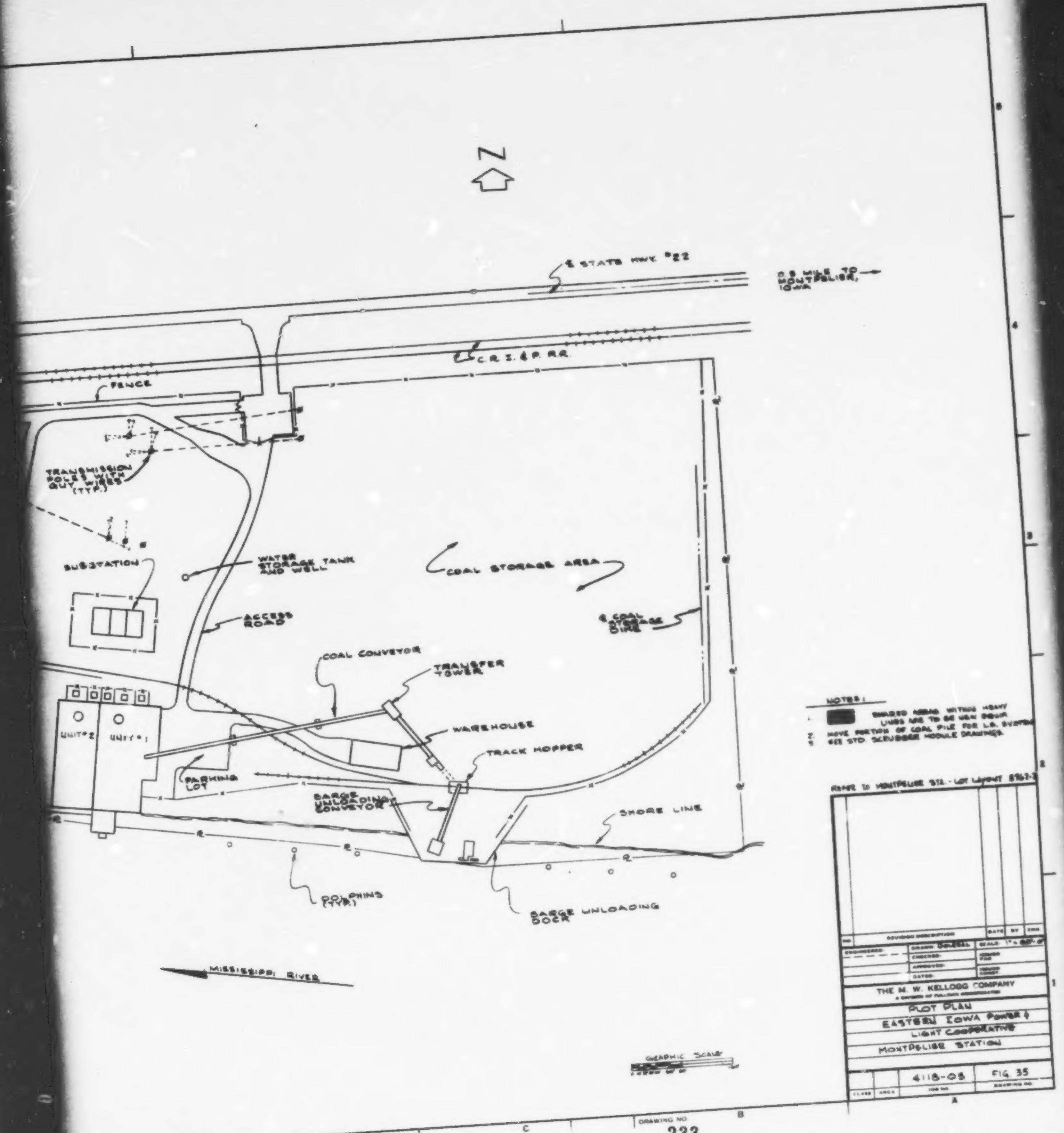
PLOT PLAN

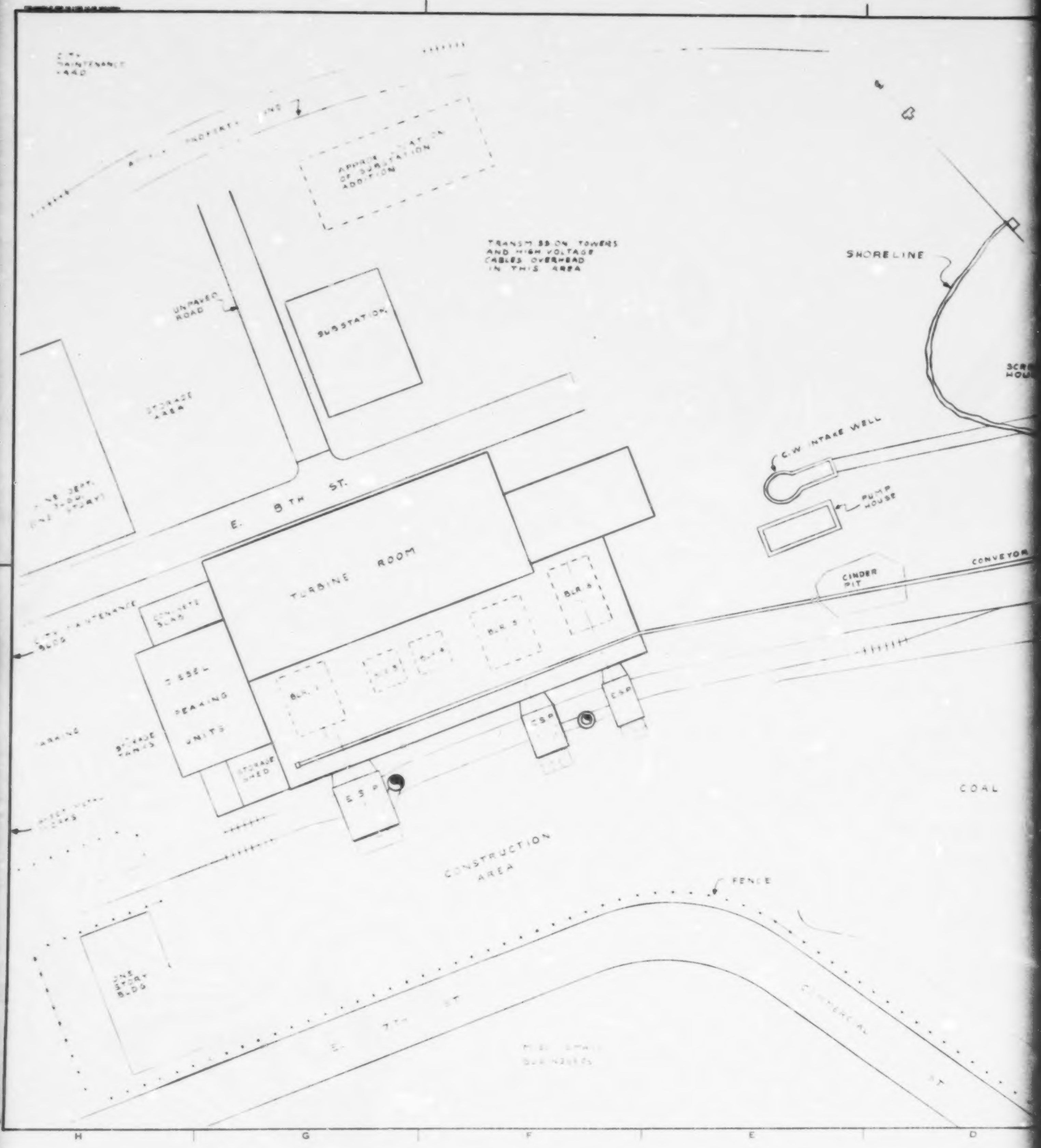
CLASS	AREA	JOB NO	DRAWING NO
		4118-03	FIG. 33

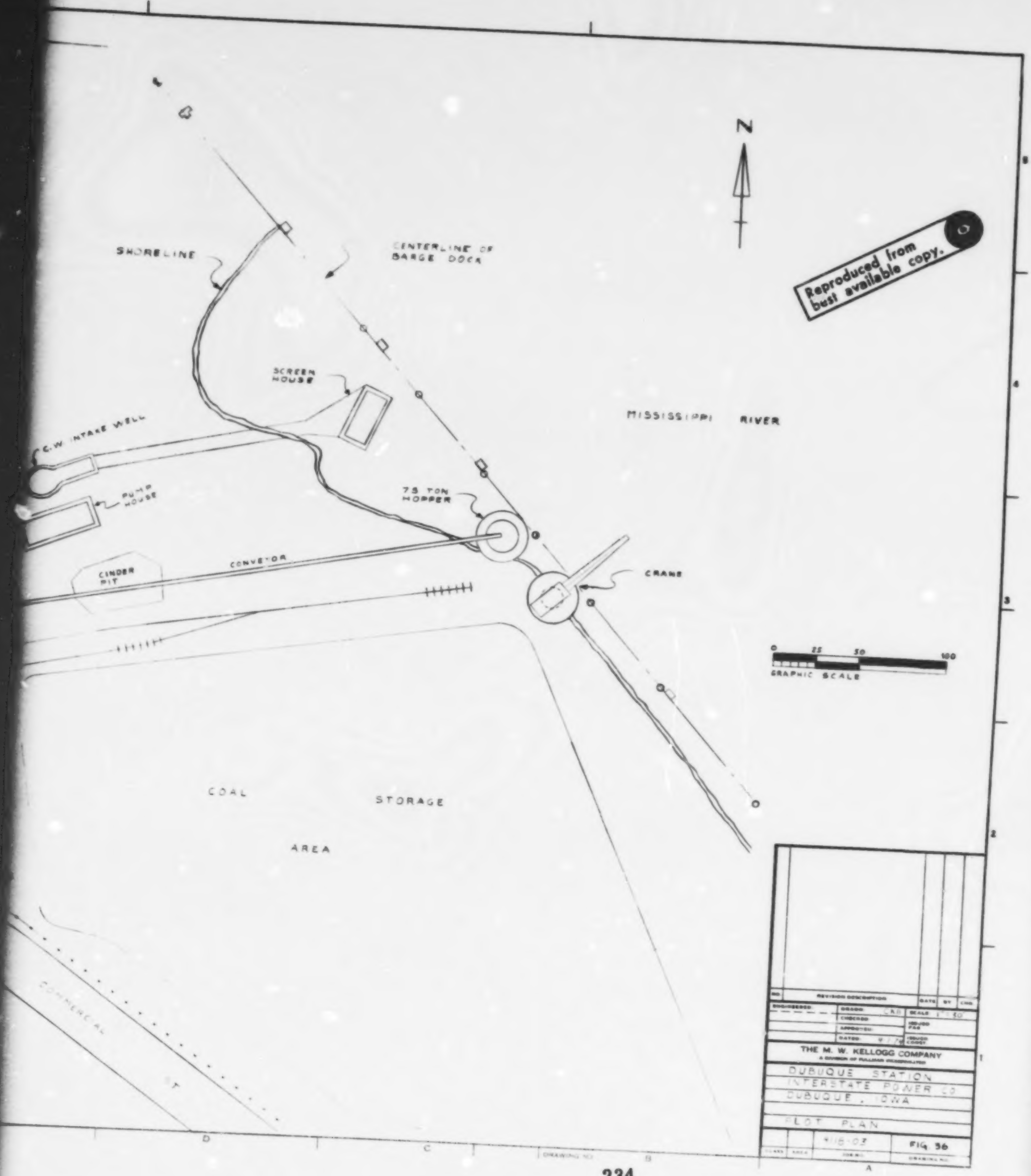

FILTER PLANT
RESERVOIR
UNDERGROUND RESERVOIR
NORTH
GRADE EL. 900'-0
15 KV 600 A. POWER LINES OVERHEAD
UNIT #1
UNIT #2
ASH SILO
ROOF EL. 965 6
STACK #2
ROOF EL. 975-8
STACK #1
UNIT #6
UNIT #5
UNIT #3
ROOF EL. 944'-10"
GRADE EL. 912-0
WALLACE ROAD
GRAPH
0
20'
H
G
F
E
D


NORTH WESTERN R.R.
15 KV 600 A.
POWER LINES
OVERHEAD
SILO
GRAPHIC SCALE
0'
20'
40'
60'
80'
100'
N
NO.
REVISION DESCRIPTION
DATE
BY
CHK
ENGINEERED
DRAWN C BRUN
CHECKED
APPROVED
DATED
SCALE 1" = 20'
ISSUED FAB
ISSUED CONST
THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED
IOWA STATE UNIVERSITY
POWER PLANT
AMES, IOWA
PLOT PLAN
4118-03
FIG. 34
CLASS
AREA
JOB NO.
DRAWING NO.
D
C
B
A
DRAWING NO.
5
4
3
2
1


FENCE
POLE YARD
ASH POND
ASH POND
TRANSMISSION POLES WITH GUY WIRES (TYP.)
SUBSTATION
WATER STORA
AND W
ACCESS ROAD
UNIT #2
UNIT #1
PARKING LOT
MISSISSIPPI RIVER
H
G
F
E
D
D
22X34


N
℄ STATE HWY. #22
0.5 MILE TO MONTPELIER, IOWA
C.R.I. & P. RR.
FENCE
TRANSMISSION POLES WITH GUY WIRES (TYP.)
SUBSTATION
WATER STORAGE TANK AND WELL
COAL STORAGE AREA
ACCESS ROAD
℄ COAL STORAGE DIKE
COAL CONVEYOR
TRANSFER TOWER
WAREHOUSE
TRACK HOPPER
UNIT #2
UNIT #1
PARKING LOT
BARGE UNLOADING CONVEYOR
SHORE LINE
DOLPHINS (TYP.)
BARGE UNLOADING DOCK
MISSISSIPPI RIVER
GRAPHIC SCALE
NOTES:
1. SHADED AREAS WITHIN HEAVY LINES ARE TO BE NEW EQUIP.
2. MOVE PORTION OF COAL PILE FOR L.S. SYSTEM
3. SEE STD. SCRUBBER MODULE DRAWINGS.
REFER TO MONTPELIER STA. - LOT LAYOUT 8763-
REVISION DESCRIPTION
DATE
BY
CHK
ENGINEERED
DRAWN
CHECKED
APPROVED
DATED
SCALE 1" =
THE M. W. KELLOGG COMPANY
PLOT PLAN
EASTERN IOWA POWER & LIGHT COOPERATIVE
MONTPELIER STATION
CLASS
AREA
4118-03
JOB NO.
FIG. 35
DRAWING NO.
A
B
C
D
E
1
2


CITY MAINTENANCE YARD
PROPERTY LINE
APPROX. LOCATION OF SUBSTATION ADDITION
TRANSMISSION TOWERS AND HIGH VOLTAGE CABLES OVERHEAD IN THIS AREA
SHORELINE
UNPAVED ROAD
SUBSTATION
STORAGE AREA
SCRE HOU
C.W. INTAKE WELL
PUMP HOUSE
E. 8TH ST.
TURBINE ROOM
CONVEYOR
CINDER PIT
BLR. 6
BLR. 5
BLR. 4
BLR. 3
BLR. 1
CONCRETE SLAB
CITY MAINTENANCE BLDG
DIESEL PEAKING UNITS
PARKING
STORAGE TANKS
STORAGE SHED
ESP
ESP
ESP
COAL
CONSTRUCTION AREA
FENCE
ONE STORY BLDG
E. 7TH ST
COMMERCIAL ST
H
G
F
E
D


N
SHORELINE
CENTERLINE OF BARGE DOCK
SCREEN HOUSE
C.W. INTAKE WELL
PUMP HOUSE
MISSISSIPPI RIVER
75 TON HOPPER
CRANE
CINDER PIT
CONVEYOR
0
25
50
100
GRAPHIC SCALE
COAL STORAGE AREA
COMMERCIAL ST
REVISION DESCRIPTION
DATE
BY
CHK
DRAWN CKB
CHECKED
APPROVED
DATED 9-1-74
SCALE 1" = 50'
THE M. W. KELLOGG COMPANY
DUBUQUE STATION
INTERSTATE POWER CO
DUBUQUE, IOWA
PLOT PLAN
4116-03
JOB NO.
FIG. 56
DRAWING NO.
A
B
C
D
1
2
3
4

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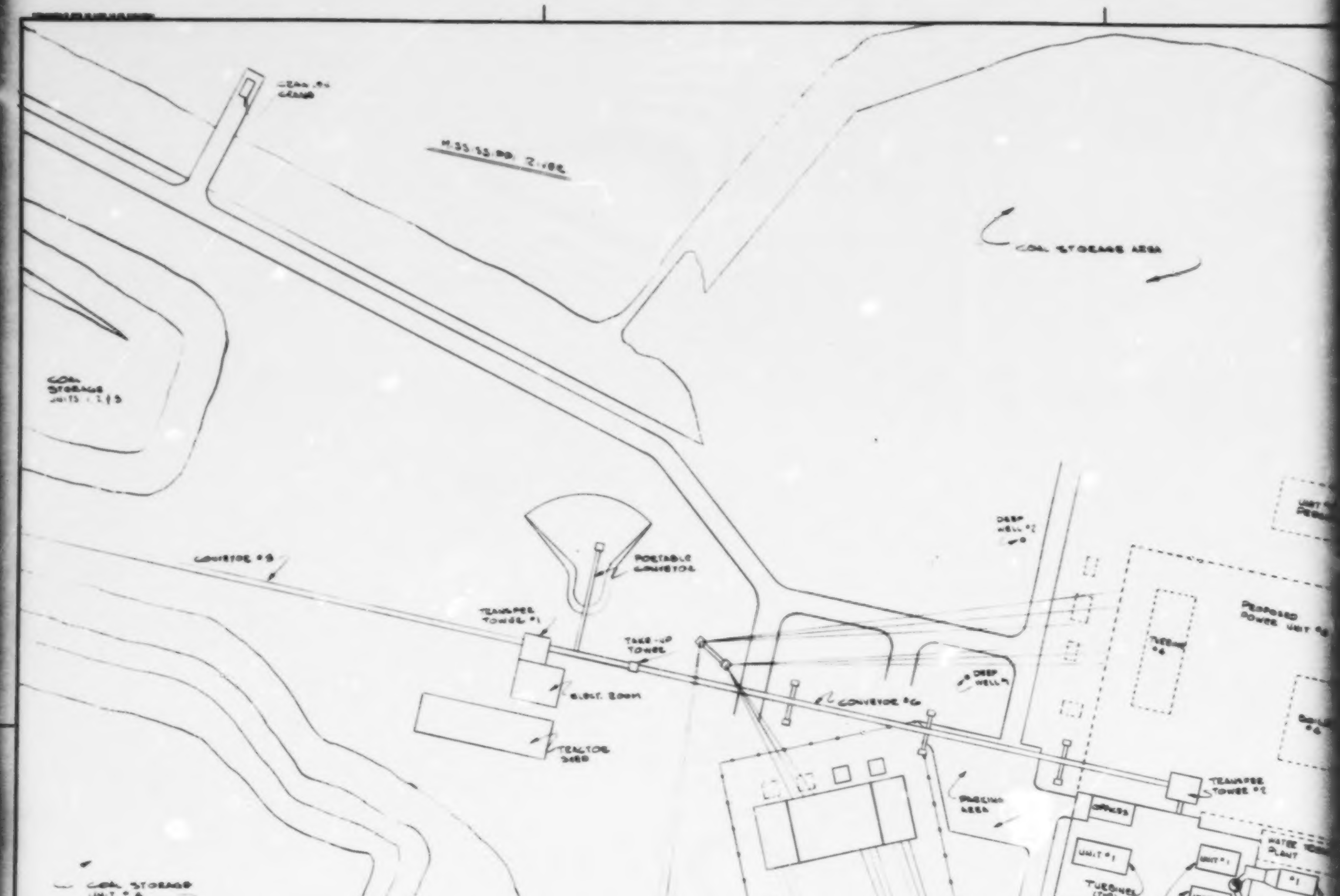
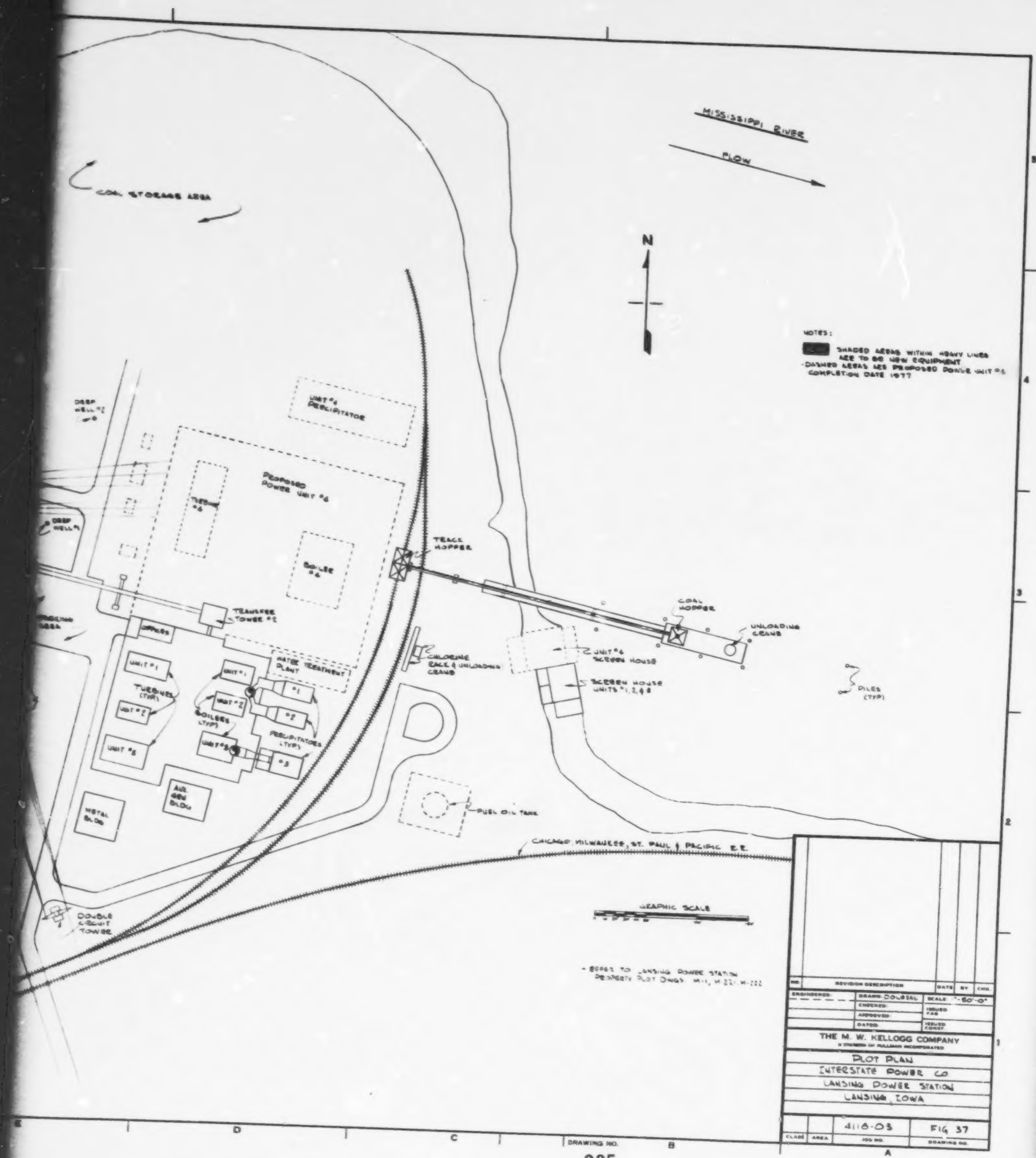

DRAG-ON CRANE
MISSISSIPPI RIVER
COAL STORAGE AREA
COAL STORAGE UNITS 1, 2 & 3
CONVEYOR #5
PORTABLE CONVEYOR
TRANSFER TOWER #1
TAKE-UP TOWER
ELECT. ROOM
TRACTOR SHED
DEEP WELL #2
CONVEYOR #6
DEEP WELL #1
PROPOSED POWER UNIT #6
TURBINE #6
BOILER #6
UNIT #6 PROPOSED
TRANSFER TOWER #2
PARKING AREA
OFFICES
WATER TREATMENT PLANT
UNIT #1
UNIT #2
UNIT #3
TURBINES (TYP)
UNIT #1
UNIT #2
UNIT #3
BOILERS (TYP)
#1
#2
#3
PRECIPITATORS (TYP)
AIR GEN BLDG
METAL BLDG
COAL STORAGE UNIT #4
SWITCHYARD & SUBSTATION
DOUBLE CIRCUIT TOWER
SEAL WELL
FLOW
CREEK
R.R. SPUR
H
G
F
E
D


MISSISSIPPI RIVER
FLOW
N
COAL STORAGE AREA
NOTES:
SHADED AREAS WITHIN HEAVY LINES ARE TO BE NEW EQUIPMENT
-DASHED AREAS ARE PROPOSED POWER UNIT #6 COMPLETION DATE 1977
DEEP WELL #2
DEEP WELL #1
UNIT #6 PRECIPITATOR
PROPOSED POWER UNIT #6
TURBINE #6
BOILER #6
TRACK HOPPER
TRANSFER TOWER #2
OFFICES
PARKING AREA
WATER TREATMENT PLANT
UNIT #1
UNIT #2
UNIT #3
TURBINES (TYP)
BOILERS (TYP)
PRECIPITATORS (TYP)
#1
#2
#3
CHLORINE RACK & UNLOADING CRANE
AIR GEN BLDG
METAL BLDG
FUEL OIL TANK
COAL HOPPER
UNLOADING CRANE
UNIT #6 SCREEN HOUSE
SCREEN HOUSE UNITS #1, 2, & 3
PILES (TYP)
CHICAGO MILWAUKEE, ST. PAUL & PACIFIC R.R.
DOUBLE CIRCUIT TOWER
GRAPHIC SCALE
- REFER TO LANSING POWER STATION PROPERTY PLOT DWGS. M-11, M-221, M-222
NO.
REVISION DESCRIPTION
DATE
BY
CHK.
ENGINEERED
DRAWN COLBIAL
CHECKED
APPROVED
DATED
SCALE 1"-50'-0"
ISSUED FAB
ISSUED CONST
THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED
PLOT PLAN
INTERSTATE POWER CO
LANSING POWER STATION
LANSING, IOWA
4118-03
FIG 37
CLASS
AREA
JOB NO.
DRAWING NO.
E
D
C
B
A
1
2
3
4
5

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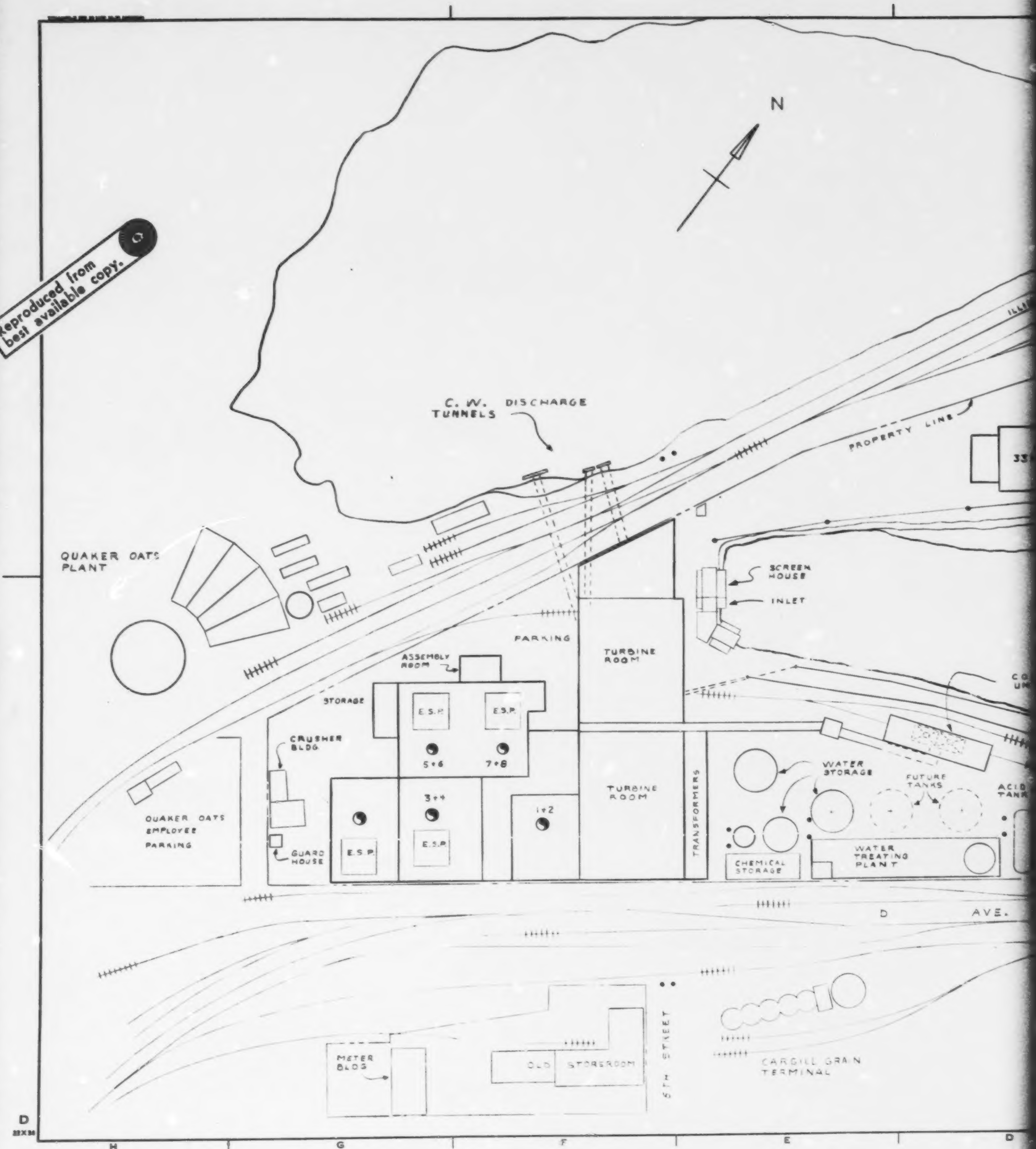
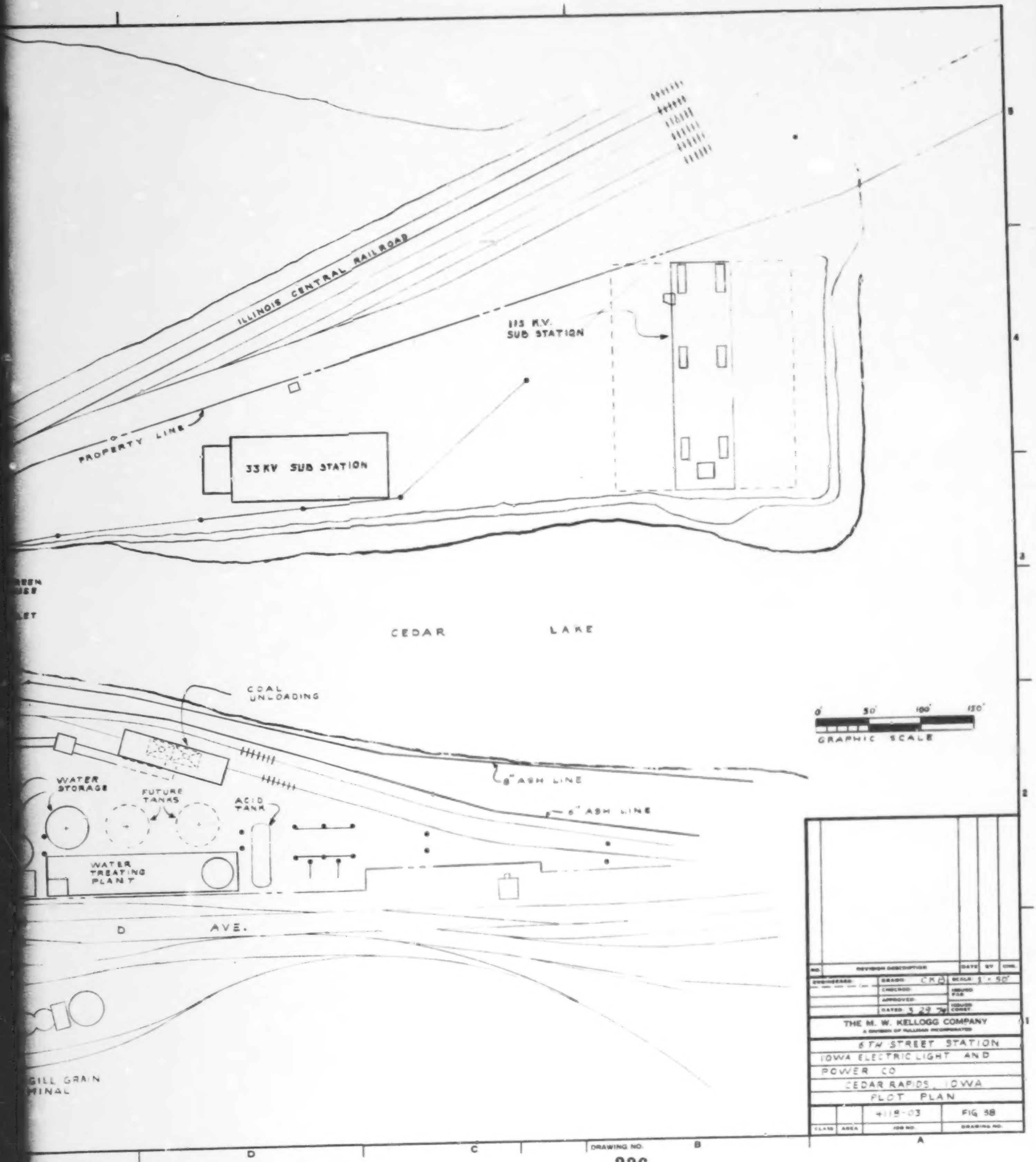

N
C. W. DISCHARGE TUNNELS
PROPERTY LINE
QUAKER OATS PLANT
SCREEN HOUSE
INLET
PARKING
TURBINE ROOM
ASSEMBLY ROOM
STORAGE
E.S.P.
E.S.P.
5+6
7+8
CRUSHER BLDG
3+4
1+2
TURBINE ROOM
TRANSFORMERS
WATER STORAGE
FUTURE TANKS
ACID TANK
QUAKER OATS EMPLOYEE PARKING
GUARD HOUSE
E.S.P.
E.S.P.
CHEMICAL STORAGE
WATER TREATING PLANT
D AVE.
METER BLDG
OLD STOREROOM
5TH STREET
CARGILL GRAIN TERMINAL
D
22X36
H
G
F
E
D


ILLINOIS CENTRAL RAILROAD
PROPERTY LINE
115 K.V.
SUB STATION
33 KV SUB STATION
CEDAR LAKE
COAL
UNLOADING
WATER
STORAGE
FUTURE
TANKS
ACID
TANK
WATER
TREATING
PLANT
8" ASH LINE
6" ASH LINE
D AVE.
GILL GRAIN
MINAL
0' 50' 100' 150'
GRAPHIC SCALE
NO. REVISION DESCRIPTION DATE BY CHK.
ENGINEERED
DRAWN CKB
CHECKED
APPROVED
DATED 3 29 74
SCALE 1" = 50'
ISSUED FOR
ISSUED CONST.
CLASS AREA JOB NO. DRAWING NO.
A
B
C
D
DRAWING NO.

THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED

6TH STREET STATION
IOWA ELECTRIC LIGHT AND
POWER CO
CEDAR RAPIDS, IOWA
PLOT PLAN

4119-03
FIG 38

APPENDIX F

CONVERSION FROM ENGLISH TO METRIC UNITS

To Convert from	To	Multiply by
acre	meter^2	4046.9
atmosphere (normal)	bar	1.01325
atmosphere (normal)	pascal	101,325
barrel (42 US gallons)	meter^3	0.15899
British thermal unit (Btu)	joule	1055.1
Btu/hour	watt	0.29307
Btu/pound mass	joules/gram	2.32600
Btu/pound mass - $^\circ$F	joules/gram - $^\circ$K	4.18680
foot	meter	0.30480
foot^2	meter^2	0.09290
foot^3	meter^3	0.02832
foot^3/minute	meter^3/minute	0.02832
foot-pound force	joule	1.35582
gallon (US)	meter^3	0.00379
gallon (US)/minute	meter^3/hour	0.22712
grain	milligram	64.7989
horsepower	kilowatt	0.74570
inch	centimeter	2.5400
inch H_2O(60 $^\circ$F)	kilopascal	0.24884
mile (US statute)	kilometer	1.60934
pound force	newton	4.44822
pound mass av	kilogram	0.45359
pound mass av	metric ton (tonne)	0.0004536
pound force/inch^2	kilopascal	6.89476
pound mass/foot^3	kilograms/meter^3	16.0185
$^\circ$Rankine	$^\circ$Kelvin	0.55556
ton mass (US short)	kilogram	907.185
ton mass (US long)	kilogram	1016.05
yard	meter	0.91440
yard^3	meter^3	0.76455

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APPENDIX G

LINEAR COMPUTER PROGRAM PRINT-OUTS (ABRIDGED)

Linear Computer Program Print-outs (Abridged)

DEFINITION OF TERMS IN LINEAR COMPUTER PROGRAM PRINT-OUT

COSTTOTL	Total system cost: $/D
TPIT	Total coal pithead cost: $/D
TFRT	Total freight cost: $/D
TASH	Total ash disposal cost at power plant: $/D
TSC1	Total capital based scrubbing cost: $/D
TSC2	Total sulfur related scrubbing cost: $/D
TWSH	Total coal cleaning cost: $/D
TREF	Total refuse disposal cost from coal cleaning plant: $/D
TSTO	Total storage/transfer cost (whether at a transfer point or cleaning plant): $/D
TBRN	Arbitrary penalty assigned if system cannot meet specification: $/D
AML	Total coal used from each mine: T/D
DDL	Total energy requirement of each power plant: MMBtu/D
EDL	Total SO_2 emission from each power plant:PPD
WMLDL	Uncleaned coal shipped directly from a mine to a power plant: T/D
WS ML SL	Same as WMLDL but scrubbed at power plant SL: T/D
X ML PL DL	Uncleaned coal shipped from a mine to a power plant via an intermediate point (PL): T/D
XS ML PL DL	Same as X ML PL DL but scrubbed at power plant SL: T/D
Y ML CL DL	Coal shipped from a mine to a cleaning plant (CL), cleaned, and then shipped to a power plant: T/D
YS ML CL SL	Same as Y ML CL DL but scrubbed at power plant SL: T/D
SS1SL	Size of scrubbing system installed at power plant SL: MMBtu/D

SS2SL	(MMBtu/D) (%S)
SM SL	Variable used in KELPLAN'S model to simulate the scrubbing system at power plant SL
CC1 CL	Size of cleaning plant installed at location CL: T/D feed
C N CL	Same as SM SL but for cleaning system
IN12SL or IN23SL	Scrubbing plant indicator (integer variable). If equal to zero, plant does not exist; if equal to one, plant exists (at SL).
IM12CL	Cleaning plant indicator (integer variable). If equal to zero, plant does not exist; if equal to one, plant exists (at CL).

Case 1: Spec. = 20 lb SO_2/MMBtu

```
.MPSX-PTF16.   EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 4                                               PAGE    39  -  74/212

SECTION 1 - ROWS

NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

     1  COSTTOTL  BS   318475.25054   318475.25054-            NONE            NONE        1.00000
     2  COSTPIT   EQ         .              .               .               .              1.00000
     3  COSTFRT   EQ         .              .               .               .              1.00000
     4  COSTASH   EQ         .              .               .               .              1.00000
     5  COSTSC1   EQ         .              .               .               .               .
     6  COSTSC2   EQ         .              .               .               .              1.00000
     7  COSTWSH   EQ         .              .               .               .              1.00000
     8  COSTREF   EQ         .              .               .               .             29.29178-
     9  COSTSTO   EQ         .              .               .               .              1.00000
    10  COSTBRN   EQ         .              .               .               .              1.00000
    11  AMA       BS     8650.43311    41349.56689          NONE      50000.00000           .
    12  AMB       BS         .         50000.00000          NONE      50000.00000           .
    13  AMC       BS     9499.41084    40500.58916          NONE      50000.00000           .
    14  AMD       BS    11383.36038    38616.63962          NONE      50000.00000           .
    15  AME       BS         .         50000.00000          NONE      50000.00000           .
    16  AMF       BS     7097.99399    42902.00601          NONE      50000.00000           .
    17  AMG       BS         .         50000.00000          NONE      50000.00000           .
    18  AMH       BS         .         50000.00000          NONE      50000.00000           .
    19  DDA       EQ    18684.00000         .         18684.00000     18684.00000          .34358-
    20  DDB       EQ    12994.00000         .         12994.00000     12994.00000          .34358-
    21  DDC       EQ    17726.00000         .         17726.00000     17726.00000          .38662-
    22  DDD       EQ    20023.00000         .         20023.00000     20023.00000          .43381-
    23  DDE       EQ    24504.00000         .         24504.00000     24504.00000          .41373-
    24  DDF       EQ    59525.00000         .         59525.00000     59525.00000          .39867-
    25  DDG       EQ    64862.00000         .         64862.00000     64862.00000          .47599-
    26  DDH       EQ    64937.00000         .         64937.00000     64937.00000          .47599-
    27  DDI       EQ    43219.00000         .         43219.00000     43219.00000          .39444-
    28  DDJ       EQ    67512.00000         .         67512.00000     67512.00000          .39114-
    29  DDK       EQ    33461.00000         .         33461.00000     33461.00000          .49105-
    30  DDL       EQ    87017.00000         .         87017.00000     87017.00000          .39307-
    31  DDM       EQ    31570.00000         .         31570.00000     31570.00000          .46043-
    32  DDN       EQ   115682.00000         .        115682.00000    115682.00000          .36617-
    33  DDO       EQ    25608.00000         .         25608.00000     25608.00000          .32676-
    34  DDP       EQ    51307.00000         .         51307.00000     51307.00000          .35725-
    35  DDQ       EQ    31488.00000         .         31488.00000     31488.00000          .38235-
    36  DDR       EQ    18259.00000         .         18259.00000     18259.00000          .36581-
    37  EDA       BS   253180.45174   120499.54826          NONE     373680.00000           .
    38  EDB       BS   176077.22061    83802.77939          NONE     259880.00000           .
    39  EDC       BS    91959.86293   262560.13707          NONE     354520.00000           .
    40  EDD       BS   103876.35876   296583.64124          NONE     400460.00000           .
    41  EDE       BS   127123.12316   362956.87684          NONE     490080.00000           .
    42  EDF       BS   308806.88485   881693.11514          NONE    1190499.99999           .
    43  EDG       BS   762474.61583   534765.38416          NONE    1297239.99999           .
    44  EDH       BS   763356.26604   535383.73395          NONE    1298739.99999           .
    45  EDI       BS   585645.79019   278734.20981          NONE     864380.00000           .
    46  EDJ       BS   350242.25804   999997.74195          NONE    1350239.99999           .
    47  EDK       BS    57328.97398   611891.02602          NONE     669220.00000           .
    48  EDL       BS  1179137.41006   561202.58994          NONE    1740340.00000           .
    49  EDM       BS   427794.20154   203605.79845          NONE     631400.00000           .
```

```
  NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

      50  EDN       BS  198198.80960   2115441.19039          NONE   2313639.99999        .
      51  EDO       BS  301030.64910    211129.35089          NONE    512160.00000        .
      52  EDP       BS  266173.11787    759966.88213          NONE   1026140.00000        .
      53  EDQ       BS  163355.08089    466404.91910          NONE    629759.99999        .
      54  EDR       BS  214640.68346    150539.31654          NONE    365180.00000        .
 A    55  SIZXDF    EQ       .               .              .               .             .
 A    56  SIZXDG    EQ       .               .              .               .             .
 A    57  SIZXDI    EQ       .               .              .               .             .
 A    58  SIZXDJ    EQ       .               .              .               .             .
 A    59  SIZXDL    EQ       .               .              .               .             .
      60  SIZXDM    EQ       .               .              .               .             .18274-
 A    61  SIZXDP    EQ       .               .              .               .             .
 A    62  SIZXDQ    EQ       .               .              .               .             .
      63  EQ1DF     BS       .               .            NONE              .             .
 A    64  EQ1DG     UL       .               .            NONE              .             .
 A    65  EQ1DI     UL       .               .            NONE              .             .
 A    66  EQ1DJ     UL       .               .            NONE              .             .
 A    67  EQ1DL     UL       .               .            NONE              .             .
      68  EQ1DM     UL       .               .            NONE              .        14473.09965
 A    69  EQ1DP     UL       .               .            NONE              .             .
 A    70  EQ1DQ     UL       .               .            NONE              .             .
      71  EQ2DF     BS       .               .            NONE              .             .
      72  EQ2DG     BS       .               .            NONE              .             .
      73  EQ2DI     BS       .               .            NONE              .             .
      74  EQ2DJ     BS       .               .            NONE              .             .
      75  EQ2DL     BS       .               .            NONE              .             .
      76  EQ2DM     UL       .               .            NONE              .         2412.18328
      77  EQ2DP     BS       .               .            NONE              .             .
      78  EQ2DQ     BS       .               .            NONE              .             .
 A    79  EQ3DF     UL       .               .            NONE              .             .
      80  EQ3DG     BS       .               .            NONE              .             .
      81  EQ3DI     BS       .               .            NONE              .             .
      82  EQ3DJ     BS       .               .            NONE              .             .
      83  EQ3DL     BS       .               .            NONE              .             .
      84  EQ3DM     UL       .               .            NONE              .        14473.09965
 A    85  EQ3DP     UL       .               .            NONE              .             .
      86  EQ3DQ     BS       .               .            NONE              .             .
      87  EQ5DF     BS       .            1.00000         NONE           1.00000          .
      88  EQ5DG     BS       .            1.00000         NONE           1.00000          .
      89  EQ5DI     BS       .            1.00000         NONE           1.00000          .
      90  EQ5DJ     BS       .            1.00000         NONE           1.00000          .
      91  EQ5DL     BS       .            1.00000         NONE           1.00000          .
      92  EQ5DM     BS       .            1.00000         NONE           1.00000          .
      93  EQ5DP     BS       .            1.00000         NONE           1.00000          .
      94  EQ5DQ     BS       .            1.00000         NONE           1.00000          .
 A    95  EQ6DF     EQ       .               .              .               .             .
 A    96  EQ6DG     EQ       .               .              .               .             .
 A    97  EQ6DI     EQ       .               .              .               .             .
 A    98  EQ6DJ     EQ       .               .              .               .             .
 A    99  EQ6DL     EQ       .               .              .               .             .
     100  EQ6DM     EQ       .               .              .               .        16885.28293-
  NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

 A   101  EQ6DP     EQ        .               .               .               .               .
 A   102  EQ6DQ     EQ        .               .               .               .               .
     103  HDF       EQ        .               .               .               .             .09765-
 A   104  HDG       EQ        .               .               .               .               .
 A   105  HDI       EQ        .               .               .               .               .
 A   106  HDJ       EQ        .               .               .               .               .
 A   107  HDL       EQ        .               .               .               .               .
     108  HDM       EQ        .               .               .               .             .18274-
 A   109  HDP       EQ        .               .               .               .               .
 A   110  HDQ       EQ        .               .               .               .               .
     111  JDF       EQ        .               .               .               .             .03150
 A   112  JDG       EQ        .               .               .               .               .
 A   113  JDI       EQ        .               .               .               .               .
 A   114  JDJ       EQ        .               .               .               .               .
 A   115  JDL       EQ        .               .               .               .               .
     116  JDM       EQ        .               .               .               .             .03150
     117  JDP       EQ        .               .               .               .             .03150
 A   118  JDQ       EQ        .               .               .               .               .
     119  SIZYDN    EQ        .               .               .               .             .38412-
     120  SIZYDP    EQ        .               .               .               .            1.90000
     121  SIZYMA    EQ        .               .               .               .            1.90000
     122  SIZYMB    EQ        .               .               .               .            1.90000
     123  SIZYMC    EQ        .               .               .               .            1.90000
     124  SIZYMD    EQ        .               .               .               .            1.90000
     125  SIZYPA    EQ        .               .               .               .            1.90000
     126  SIZYPB    EQ        .               .               .               .             .22675
 A   127  EQ03DN    EQ        .               .               .               .               .
 A   128  EQ03DP    EQ        .               .               .               .               .
 A   129  EQ03MA    EQ        .               .               .               .               .
 A   130  EQ03MB    EQ        .               .               .               .               .
 A   131  EQ03MC    EQ        .               .               .               .               .
 A   132  EQ03MD    EQ        .               .               .               .               .
 A   133  EQ03PA    EQ        .               .               .               .               .
 A   134  EQ03PB    EQ        .               .               .               .               .
     135  FDN       EQ        .               .               .               .             .38412-
     136  FDP       EQ        .               .               .               .            1.90000
     137  FMA       EQ        .               .               .               .            1.90000
     138  FMB       EQ        .               .               .               .            1.90000
     139  FMC       EQ        .               .               .               .            1.90000
     140  FMD       EQ        .               .               .               .            1.90000
     141  FPA       EQ        .               .               .               .            1.90000
     142  FPB       EQ        .               .               .               .             .22675
```

```
SECTION 2 - COLUMNS

 NUMBER  .COLUMN.  AT   ...ACTIVITY...   ..INPUT COST..   ..LOWER LIMIT.   ..UPPER LIMIT.  .REDUCED COST.

    145  WMCDA     BS      917.32129           .                .              NONE            .
    153  WMCCB     BS      637.96151           .                .              NONE            .
    191  WMADG     BS     3230.82464           .                .              NONE            .
    199  WMADH     BS     3234.56045           .                .              NONE            .
    209  WMCDI     BS     2121.90691           .                .              NONE            .
    233  WMCDL     BS     4272.24077           .                .              NONE            .
    241  WMCDM     BS     1549.98036           .                .              NONE            .
    252  WMFDN     BS     5505.52249           .                .              NONE            .
    255  WMADO     BS     1275.55360           .                .              NONE            .
    266  WMDDP     BS     2146.55740           .                .              NONE            .
    279  WMADR     BS      909.49442           .                .              NONE            .
    295  WSMADG    BS          .               .                .              NONE            .
    305  WSMCDI    BS          .               .                .              NONE            .
    321  WSMCDL    BS          .               .                .              NONE            .
    938  XMDDPDC   BS      741.61180           .                .              NONE            .
   1146  XMCDPDD   BS      837.71257           .                .              NONE            .
   1354  XMCDPDE   BS     1025.18648           .                .              NONE            .
   1562  XMDDPDF   BS     2490.37810           .                .              NONE            .
   2394  XMCDPDJ   BS     2824.53434           .                .              NONE            .
   2588  XMFDNDK   BS     1592.47150           .                .              NONE            .
   3858  XMDDPDQ   BS     1317.37968           .                .              NONE            .
   4266  XSMDDPDF  BS          .               .                .              NONE            .
   4890  XSMDDPDJ  BS          .               .                .              NONE            .
   5306  XSMCDPDM  BS          .               .                .              NONE            .
   5730  XSMDDPDQ  BS          .               .                .              NONE            .
   6162  YMDDNDK   BS          .               .                .              NONE            .
   6517  YSMDPBCF  BS          .               .                .              NONE            .
   6689  YSMAMADM  BS          .               .                .              NONE            .
   6800  SS1DG     BS          .               .                .              NONE            .
   6801  SS1DI     BS          .               .                .              NONE            .
   6802  SS1DJ     BS          .               .                .              NONE            .
   6803  SS1DL     BS          .               .                .              NONE            .
   6804  SS1DM     BS          .               .                .              NONE            .
   6805  SS1DP     BS          .               .                .              NONE            .
   6806  SS1DQ     BS          .               .                .              NONE            .
   6807  SS2DF     BS          .               .                .              NONE            .
   6812  SS2DM     BS          .               .                .              NONE            .
   6813  SS2DP     BS          .               .                .              NONE            .
   6815  S1DF      BS          .               .                .              NONE            .
   6816  S2CF      BS          .               .                .              NONE            .
   6819  S2DG      BS          .               .                .              NONE            .
   6822  S2DI      BS          .               .                .              NONE            .
   6825  S2DJ      BS          .               .                .              NONE            .
   6828  S2DL      BS          .               .                .              NONE            .
   6830  S1DM      BS          .               .                .              NONE            .
   6831  S2DM      BS          .               .                .              NONE            .
   6833  S1DP      BS          .               .                .              NONE            .
   6834  S2DP      BS          .               .                .              NONE            .
   6835  S3DP      BS          .               .                .              NONE            .
```

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.MPSX-PTF16.   EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 4                                                  PAGE    43  -  74/212

 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

   6836  S1D0      BS          .               .               .           NONE              .
   6837  S2D0      BS          .               .               .           NONE              .
   6839  CC1DN     BS          .               .               .           NONE              .
   6840  CC1DP     BS          .               .               .           NONE              .
   6841  CC1MA     BS          .               .               .           NONE              .
   6842  CC1MB     BS          .               .               .           NONE              .
   6843  CC1MC     BS          .               .               .           NONE              .
   6844  CC1MD     BS          .               .               .           NONE              .
   6845  CC1PA     BS          .               .               .           NONE              .
   6846  CC1PB     BS          .               .               .           NONE              .
   6849  C1DP      BS          .               .               .           NONE              .
   6851  C1MA      BS          .               .               .           NONE              .
   6853  C1MB      BS          .               .               .           NONE              .
   6855  C1MC      BS          .               .               .           NONE              .
   6857  C1MD      BS          .               .               .           NONE              .
   6859  C1PA      BS          .               .               .           NONE              .
   6860  C2PA      BS          .               .               .           NONE              .
   6881  TPIT      BS   219516.61397        1.00000            .           NONE              .
   6882  TFRT      BS    90935.21831        1.00000            .           NONE              .
   6883  TASH      BS     4774.63592        1.00000            .           NONE              .
   6885  TSC2      BS          .            1.00000            .           NONE              .
   6886  TWSH      BS          .            1.00000            .           NONE              .
   6888  TSTO      BS     3248.78234        1.00000            .           NONE              .
   6889  TBRN      BS          .            1.00000            .           NONE              .
   6890  IN12DF    IV          .               .               .        1.00000              .
   6891  IN12DG    IV          .               .               .        1.00000              .
   6892  IN12DI    IV          .               .               .        1.00000              .
   6893  IN12DJ    IV          .               .               .        1.00000              .
   6894  IN12DL    IV          .               .               .        1.00000              .
   6895  IN12DM    IV          .               .               .        1.00000              .
   6898  IN23DF    IV          .               .               .        1.00000              .
   6899  IN23DG    IV          .               .               .        1.00000              .
   6900  IN23DI    IV          .               .               .        1.00000              .
   6901  IN23DJ    IV          .               .               .        1.00000              .
   6902  IN23DL    IV          .               .               .        1.00000              .
   6903  IN23DM    IV          .               .               .        1.00000              .
   6904  IN23DP    IV          .               .               .        1.00000              .
   6905  IN23DQ    IV          .               .               .        1.00000              .
   6906  IM12DN    IV          .               .               .        1.00000              .
   6907  IM12DP    IV          .               .               .        1.00000              .
   6908  IM12MA    IV          .               .               .        1.00000              .
   6909  IM12MB    IV          .               .               .        1.00000              .
   6910  IM12MC    IV          .               .               .        1.00000              .
   6911  IM12MD    IV          .               .               .        1.00000              .
   6913  IM12PB    IV          .               .               .        1.00000              .
```

Case 1: Spec. = 5 lb SO_2/MMBtu

```
MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                        PAGE    18  -  74/165

SECTION 1 - ROWS

NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

     1  COSTTOTL  BS   358183.05216   358183.05216-        NONE            NONE           1.00000
     2  COSTPIT   EQ         .              .                .               .            1.00000
     3  COSTFRT   EQ         .              .                .               .            1.00000
     4  COSTASH   EQ         .              .                .               .            1.00000
     5  COSTSC1   EQ         .              .                .               .             .25232
     6  COSTSC2   EQ         .              .                .               .            1.00000
     7  COSTWSH   EQ         .              .                .               .             .74690
     8  COSTRFF   EQ         .              .                .               .            1.00000
     9  COSTSTO   EQ         .              .                .               .            1.00000
    10  COSTBRN   EQ         .              .                .               .             .00007
    11  AMA       BS      508.37364     49491.62636         NONE        50000.00000          .
    12  AMB       BS     2406.44351     47593.55649         NONE        50000.00000          .
    13  AMC       BS      534.43454     49465.56546         NONE        50000.00000          .
    14  AMD       BS    19741.47872     30258.52128         NONE        50000.00000          .
    15  AME       BS         .          50000.00000         NONE        50000.00000          .
    16  AMF       BS     7683.51512       316.48488         NONE         8000.00000          .
    17  AMG       BS     3813.71776      4186.28224         NONE         8000.00000          .
    18  AMH       BS         .              .               NONE             .                .
    19  DDA       EQ    18684.00000         .           18684.00000     18684.00000         .66753-
    20  DDB       EQ    12994.00000         .           12994.00000     12994.00000         .66753-
    21  DDC       EQ    17726.00000         .           17726.00000     17726.00000         .49089-
    22  DDD       EQ    20023.00000         .           20023.00000     20023.00000         .54416-
    23  DDE       EQ    24504.00000         .           24504.00000     24504.00000         .52313-
    24  DDF       EQ    59525.00000         .           59525.00000     59525.00000         .50541-
    25  DDG       EQ    64862.00000         .           64862.00000     64862.00000         .59738-
    26  DDH       EQ    64937.00000         .           64937.00000     64937.00000         .59738-
    27  DDI       EQ    43219.00000         .           43219.00000     43219.00000         .66978-
    28  DDJ       EQ    67512.00000         .           67512.00000     67512.00000         .49633-
    29  DDK       EQ    33461.00000         .           33461.00000     33461.00000         .49105-
    30  DDL       EQ    87017.00000         .           87017.00000     87017.00000         .68096-
    31  DDM       EQ    31570.00000         .           31570.00000     31570.00000         .66119-
    32  DDN       EQ   115682.00000         .          115682.00000    115682.00000         .36617-
    33  DDO       EQ    25608.00000         .           25608.00000     25608.00000         .58785-
    34  DDP       EQ    51307.00000         .           51307.00000     51307.00000         .45549-
    35  DDQ       EQ    31488.00000         .           31488.00000     31488.00000         .48574-
    36  DDR       EQ    18259.00000         .           18259.00000     18259.00000         .62192-
    37  EDA       UL    93420.00000         .               NONE        93420.00000         .02391
    38  EDB       UL    64570.00000         .               NONE        64970.00000         .02391
    39  EDC       UL    88630.00000         .               NONE        88630.00000         .02010
    40  EDD       UL   100115.00000         .               NONE       100115.00000         .02127
    41  EDE       UL   122520.00000         .               NONE       122520.00000         .02109
    42  EDF       UL   297625.00000         .               NONE       297625.00000         .02058
    43  EDG       UL   324310.00000         .               NONE       324310.00000         .02174
    44  EDH       UL   324685.00000         .               NONE       324685.00000         .02174
    45  EDI       UL   216095.00000         .               NONE       216095.00000         .02237
    46  EDJ       UL   337560.00000         .               NONE       337560.00000         .02028
    47  EDK       BS    57328.97398    109976.02602         NONE       167305.00000          .
    48  EDL       UL   435085.00000         .               NONE       435085.00000         .02505
    49  EDM       UL   157850.00000         .               NONE       157850.00000         .02230
```

```
   NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

      50  EDN       BS   158198.80960    380211.19039       NONE      578410.00000          .
      51  EDO       UL   128040.00000          .            NONE      128040.00000        .02221
      52  EDP       UL   256535.00000          .            NONE      256535.00000        .01894
      53  EDQ       UL   157440.00000          .            NONE      157440.00000        .01993
      54  EDR       UL    91295.00000          .            NONE       91295.00000        .02195
      55  SIZXDF    EQ         .               .             .               .            .06490
      56  SIZXDG    EQ         .               .             .               .            .06490
      57  SIZXDI    EQ         .               .             .               .            .06490
      58  SIZXDJ    EQ         .               .             .               .            .06110
      59  SIZXDL    EQ         .               .             .               .            .06490
      60  SIZXDM    EQ         .               .             .               .            .06110
      61  SIZXDP    EQ         .               .             .               .            .06490
      62  SIZXDQ    EQ         .               .             .               .            .06110
      63  EQ1DF     BS         .               .            NONE             .              .
      64  EQ1DG     BS         .               .            NONE             .              .
      65  EQ1DI     BS         .               .            NONE             .              .
 A    66  EQ1DJ     UL         .               .            NONE             .              .
 A    67  EQ1DL     UL         .               .            NONE             .              .
 A    68  EQ1DM     UL         .               .            NONE             .              .
      69  EQ1DP     BS         .               .            NONE             .              .
 A    70  EQ1DQ     UL         .               .            NONE             .              .
      71  EQ2DF     BS         .               .            NONE             .              .
      72  EQ2DG     BS         .               .            NONE             .              .
      73  EQ2DI     BS         .               .            NONE             .              .
      74  EQ2DJ     UL         .               .            NONE             .              .
      75  EQ2DL     BS         .               .            NONE             .         601.71767
      76  EQ2DM     UL         .               .            NONE             .              .
      77  EQ2DP     BS         .               .            NONE             .         601.71767
      78  EQ2DQ     UL         .               .            NONE             .              .
      79  EQ3DF     UL         .               .            NONE             .         601.71767
 A    80  EQ3DG     UL         .               .            NONE             .         551.57453
      81  EQ3DI     BS         .               .            NONE             .              .
      82  EQ3DJ     BS         .               .            NONE             .              .
      83  EQ3DL     BS         .               .            NONE             .              .
      84  EQ3DM     BS         .               .            NONE             .              .
      85  EQ3DP     BS         .               .            NONE             .              .
      86  EQ3DQ     BS         .               .            NONE             .              .
      87  EQ5DF     BS         .            1.00000         NONE          1.00000           .
      88  EQ5DG     BS         .            1.00000         NONE          1.00000           .
      89  EQ5DI     BS         .            1.00000         NONE          1.00000           .
      90  EQ5DJ     BS         .            1.00000         NONE          1.00000           .
      91  EQ5DL     BS         .            1.00000         NONE          1.00000           .
      92  EQ5DM     BS         .            1.00000         NONE          1.00000           .
      93  EQ5DP     BS         .            1.00000         NONE          1.00000           .
      94  EQ5DQ     BS         .            1.00000         NONE          1.00000           .
      95  EQ6DF     EQ         .               .             .               .              .
 A    96  EQ6DG     EQ         .               .             .               .         551.57453-
 A    97  EQ6DI     EQ         .               .             .               .              .
      98  EQ6DJ     EQ         .               .             .               .              .
 A    99  EQ6DL     EQ         .               .             .               .         601.71767-
     100  EQ6DM     EQ         .               .             .               .         601.71767-
```

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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                   PAGE    20 -  74/165
   NUMBER  ...ROW..  AT   ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY
 A   101  EQ6DP     EQ         .               .               .               .               .
     102  EQ6DQ     EQ         .               .               .               .          601.71767-
     103  HDF       EQ         .               .               .               .             .06490
     104  HDG       EQ         .               .               .               .             .06490
     105  HDI       EQ         .               .               .               .             .06490
     106  HDJ       EQ         .               .               .               .             .06110
     107  HDL       EQ         .               .               .               .             .06490
     108  HDM       EQ         .               .               .               .             .06110
     109  HDP       EQ         .               .               .               .             .06490
     110  HDQ       EQ         .               .               .               .             .06110
     111  JDF       EQ         .               .               .               .             .01006
     112  JDG       EQ         .               .               .               .             .03150
     113  JDI       EQ         .               .               .               .             .02685
     114  JDJ       EQ         .               .               .               .             .01083
     115  JDL       EQ         .               .               .               .             .03150
     116  JDM       EQ         .               .               .               .             .01586
     117  JDP       EQ         .               .               .               .             .00759
     118  JDQ       EQ         .               .               .               .             .01031
     119  SIZYDN    EQ         .               .               .               .            1.41912
     120  SIZYDP    EQ         .               .               .               .             .35558-
     121  SIZYMA    EQ         .               .               .               .            1.41912
     122  SIZYMB    EQ         .               .               .               .            1.41912
     123  SIZYMC    EQ         .               .               .               .            1.41912
     124  SIZYMD    EQ         .               .               .               .            1.41912
     125  SIZYPA    EQ         .               .               .               .            1.41912
     126  SIZYPB    EQ         .               .               .               .            1.41912
 A   127  EQ03DN    EQ         .               .               .               .               .
 A   128  EQ03DP    EQ         .               .               .               .               .
 A   129  EQ03MA    EQ         .               .               .               .               .
 A   130  EQ03MB    EQ         .               .               .               .               .
 A   131  EQ03MC    EQ         .               .               .               .               .
 A   132  EQ03MD    EQ         .               .               .               .               .
 A   133  EQ03PA    EQ         .               .               .               .               .
 A   134  EQ03PB    EQ         .               .               .               .               .
     135  FDN       EQ         .               .               .               .            1.41912
     136  FDP       EQ         .               .               .               .             .35558-
     137  FMA       EQ         .               .               .               .            1.41912
     138  FMB       EQ         .               .               .               .            1.41912
     139  FMC       EQ         .               .               .               .            1.41912
     140  FMD       EQ         .               .               .               .            1.41912
     141  FPA       EQ         .               .               .               .            1.41912
     142  FPB       EQ         .               .               .               .            1.41912
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251

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SECTION 2 - COLUMNS

 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

    145  WMCDA     BS      315.21482          .               .             NONE            .
    153  WMCDB     BS      219.21972          .               .             NONE            .
    232  WMBDL     BS     2406.44351          .               .             NONE            .
    252  WMFDN     BS     5505.52249          .               .             NONE            .
    255  WMADQ     BS      508.37364          .               .             NONE            .
    266  WMDDP     BS     2030.50337          .               .             NONE            .
    268  WMFDP     BS      132.01616          .               .             NONE            .
    303  WSMADI    BS          .              .               .             NONE            .
    320  WSMBDL    BS          .              .               .             NONE            .
    329  WSMCDM    BS          .              .               .             NONE            .
    338  WSMDDP    BS          .              .               .             NONE            .
    509  XMGDNDA   BS      535.06565          .               .             NONE            .
    717  XMGDNDB   BS      372.11748          .               .             NONE            .
    938  XMDDPDC   BS      701.51642          .               .             NONE            .
    940  XMFDPDC   BS       45.61012          .               .             NONE            .
   1146  XMDDPDD   BS      803.97414          .               .             NONE            .
   1149  XMGDPDD   BS       35.18394          .               .             NONE            .
   1354  XMDDPDE   BS      983.89763          .               .             NONE            .
   1357  XMGDPDE   BS       43.05784          .               .             NONE            .
   1562  XMDDPDF   BS     2355.73534          .               .             NONE            .
   1564  XMFDPDF   BS      153.16159          .               .             NONE            .
   1770  XMDDPDG   BS     2604.37349          .               .             NONE            .
   1773  XMGDPDG   BS      113.97396          .               .             NONE            .
   1978  XMDDPDH   BS     2607.38493          .               .             NONE            .
   1981  XMGDPDH   BS      114.10575          .               .             NONE            .
   2186  XMDDPDI   BS     1735.35225          .               .             NONE            .
   2189  XMGDPDI   BS       75.94340          .               .             NONE            .
   2394  XMDDPDJ   BS     2671.82536          .               .             NONE            .
   2396  XMFDPDJ   BS      173.71265          .               .             NONE            .
   2588  XMFDNDK   BS     1592.47150          .               .             NONE            .
   2813  XMGDPDL   BS     1764.72641          .               .             NONE            .
   3018  XMDDPDM   BS     1267.61541          .               .             NONE            .
   3021  XMGDPDM   BS       55.47405          .               .             NONE            .
   3437  XMGDPDO   BS      671.98501          .               .             NONE            .
   3858  XMDDPDQ   BS     1246.15530          .               .             NONE            .
   3860  XMFDPDQ   BS       81.02062          .               .             NONE            .
   4066  XMDDPDR   BS      733.14507          .               .             NONE            .
   4069  XMGDPDR   BS       32.08428          .               .             NONE            .
   4266  XSMDDPDF  BS          .              .               .             NONE            .
   4890  XSMDDPDJ  BS          .              .               .             NONE            .
   5730  XSMDDPDQ  BS          .              .               .             NONE            .
   6087  YMDDPDI   BS          .              .               .             NONE            .
   6215  YMBMBDL   BS          .              .               .             NONE            .
   6799  SS1DF     BS          .              .               .             NONE            .
   6800  SS1DG     BS          .              .               .             NONE            .
   6801  SS1DI     BS          .              .               .             NONE            .
   6802  SS1DJ     BS          .              .               .             NONE            .
   6803  SS1DL     BS          .              .               .             NONE            .
   6804  SS1DM     BS          .              .               .             NONE            .
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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                        PAGE    22  -, 74/165
  NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

     6805  SS1DP    BS         .               .               .             NONE             .
     6806  SS1DQ    BS         .               .               .             NONE             .
     6808  SS2DG    BS         .               .               .             NONE             .
     6811  SS2DL    BS         .               .               .             NONE             .
     6815  S1DF     BS         .               .               .             NONE             .
     6817  S3DF     BS         .               .               .             NONE             .
     6820  S3DG     BS         .               .               .             NONE             .
     6823  S3DI     BS         .               .               .             NONE             .
     6824  S1DJ     BS         .               .               .             NONE             .
     6826  S3DJ     BS         .               .               .             NONE             .
     6829  S3DL     BS         .               .               .             NONE             .
     6830  S1DM     BS         .               .               .             NONE             .
     6832  S3DM     BS         .               .               .             NONE             .
     6835  S3DP     BS         .               .               .             NONE             .
     6836  S1DQ     BS         .               .               .             NONE             .
     6838  S3DQ     BS         .               .               .             NONE             .
     6839  CC1DM    BS         .               .               .             NONE             .
     6840  CC1DP    BS         .               .               .             NONE             .
     6841  CC1MA    BS         .               .               .             NONE             .
     6842  CC1MB    BS         .               .               .             NONE             .
     6843  CC1MC    BS         .               .               .             NONE             .
     6844  CC1MD    BS         .               .               .             NONE             .
     6845  CC1PA    BS         .               .               .             NONE             .
     6846  CC1PB    BS         .               .               .             NONE             .
     6847  C1DN     BS         .               .               .             NONE             .
     6851  C1MA     BS         .               .               .             NONE             .
     6853  C1MB     BS         .               .               .             NONE             .
     6855  C1MC     BS         .               .               .             NONE             .
     6857  C1MD     BS         .               .               .             NONE             .
     6858  C2MD     BS         .               .               .             NONE             .
     6859  C1PA     BS         .               .               .             NONE             .
     6861  C1PB     BS         .               .               .             NONE             .
     6874  QDL      BS         .               .               .             NONE             .
     6881  TPIT     BS  205165.08274         1.00000           .             NONE             .
     6882  TFRT     BS  141748.93762         1.00000           .             NONE             .
     6883  TASH     BS    4197.83093         1.00000           .             NONE             .
     6885  TSC2     BS         .             1.00000           .             NONE             .
     6887  TREE     BS         .             1.00000           .             NONE             .
     6888  TSTO     BS    7071.20087         1.00000           .             NONE             .
     6891  IN12DG   IV         .               .               .           1.00000            .
     6892  IN12DI   IV         .               .               .           1.00000            .
     6893  IN12DJ   IV         .               .               .           1.00000            .
     6894  IN12DL   IV         .               .               .           1.00000            .
     6895  IN12DM   IV         .               .               .           1.00000            .
     6896  IN12DP   IV         .               .               .           1.00000            .
     6897  IN12DQ   IV         .               .               .           1.00000            .
     6898  IN23DF   IV         .               .               .           1.00000            .
     6899  IN23DG   IV         .               .               .           1.00000            .
     6901  IN23DJ   IV         .               .               .           1.00000            .
     6902  IN23DL   IV         .               .               .           1.00000            .
     6903  IN23DM   IV         .               .               .           1.00000            .
  NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

    6905  IN23DD    IV        .               .               .            1.00000           .
    6906  IM12DN    IV        .               .               .            1.00000           .
    6907  IM12DP    IV        .               .               .            1.00000           .
    6908  IM12MA    IV        .               .               .            1.00000           .
    6909  IM12MB    IV        .               .               .            1.00000           .
    6910  IM12MC    IV        .               .               .            1.00000           .
    6912  IM12PA    IV        .               .               .            1.00000           .
    6913  IM12PB    IV        .               .               .            1.00000           .
```

Case 1: Spec. = 3.1 lb SO_2/MMBtu

```
SECTION 1 - ROWS

NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

     1  COSTTOTL  BS   384574.83811   384574.83811-         NONE            NONE          1.00000
     2  COSTPIT   EQ          .               .               .               .           1.00000
     3  COSTFRT   EQ          .               .               .               .           1.00000
     4  COSTASH   EQ          .               .               .               .           1.00000
     5  COSTSC1   EQ          .               .               .               .           1.00000
     6  COSTSC2   EQ          .               .               .               .           1.00000
     7  COSTWSH   EQ          .               .               .               .           1.00000
     8  COSTREF   EQ          .               .               .               .           8.37942-
     9  COSTSTO   EQ          .               .               .               .           1.00000
    10  COSTBRN   EQ          .               .               .               .            .00007
    11  AMA       BS      292.59705    49707.40295          NONE     50000.00000              .
    12  AMB       BS     1385.04147    48614.95853          NONE     50000.00000              .
    13  AMC       BS      307.59668    49692.40332          NONE     50000.00000              .
    14  AMD       BS     9978.63212    40021.36788          NONE     50000.00000              .
    15  AME       BS          .        50000.00000          NONE     50000.00000              .
    16  AMF       BS    13605.68468    36394.31532          NONE     50000.00000              .
    17  AMG       BS     9818.65797    40181.34203          NONE     50000.00000              .
    18  AMH       BS          .        50000.00000          NONE     50000.00000              .
    19  DDA       EQ    18684.00000           .        18684.00000     18684.00000           .66753-
    20  DDB       EQ    12994.00000           .        12994.00000     12994.00000           .66753-
    21  DDC       EQ    17726.00000           .        17726.00000     17726.00000           .49089-
    22  DDD       EQ    20023.00000           .        20023.00000     20023.00000           .54416-
    23  DDE       EQ    24504.00000           .        24504.00000     24504.00000           .52313-
    24  DDF       EQ    59525.00000           .        59525.00000     59525.00000           .50541-
    25  DDG       EQ    64862.00000           .        64862.00000     64862.00000           .59738-
    26  DDH       EQ    64937.00000           .        64937.00000     64937.00000           .59738-
    27  DDI       EQ    43219.00000           .        43219.00000     43219.00000           .66978-
    28  DDJ       EQ    67512.00000           .        67512.00000     67512.00000           .49633-
    29  DDK       EQ    33461.00000           .        33461.00000     33461.00000           .49105-
    30  DDL       EQ    87017.00000           .        87017.00000     87017.00000           .68096-
    31  DDM       EQ    31570.00000           .        31570.00000     31570.00000           .66119-
    32  DDN       EQ   115682.00000           .       115682.00000    115682.00000           .36617-
    33  DDO       EQ    25608.00000           .        25608.00000     25608.00000           .58785-
    34  DDP       EQ    51307.00000           .        51307.00000     51307.00000           .45549-
    35  DDQ       EQ    31488.00000           .        31488.00000     31488.00000           .48574-
    36  DDR       EQ    18259.00000           .        18259.00000     18259.00000           .62192-
    37  EDA       UL    57920.38672           .             NONE       57920.38672           .02391
    38  EDB       UL    40281.39063           .             NONE       40281.39063           .02391
    39  EDC       UL    54950.58984           .             NONE       54950.58984           .02010
    40  EDD       UL    62071.28516           .             NONE       62071.28516           .02127
    41  EDE       UL    75962.37500           .             NONE       75962.37500           .02109
    42  EDF       UL   184527.43750           .             NONE      184527.43750           .02058
    43  EDG       UL   201072.12500           .             NONE      201072.12500           .02174
    44  EDH       UL   201304.62500           .             NONE      201304.62500           .02174
    45  EDI       UL   133978.87500           .             NONE      133978.87500           .02237
    46  EDJ       UL   209287.12500           .             NONE      209287.12500           .02028
    47  EDK       BS    57328.97398    46400.08852          NONE      103729.06250              .
    48  EDL       UL   269752.62500           .             NONE      269752.62500           .02505
    49  EDM       UL    97866.93750           .             NONE       97866.93750           .02230
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 NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY. ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

    50   EDN       BS  158198.30960    160415.31540          NONE       358614.12500          .
    51   EDO       UL   79384.75000          .               NONE        79384.75000         .02221
    52   EDP       UL  159051.62500          .               NONE       159051.62500         .01894
    53   EDQ       UL   97612.75000          .               NONE        97612.75000         .01993
    54   EDR       UL   56602.88672          .               NONE        56602.88672         .02195
    55   SIZXDF    EQ         .              .              .                 .              .25720
    56   SIZXDG    EQ         .              .              .                 .              .25720
    57   SIZXDI    EQ         .              .              .                 .              .25720
    58   SIZXDJ    EQ         .              .              .                 .              .24214
    59   SIZXDL    EQ         .              .              .                 .              .25720
    60   SIZXDM    EQ         .              .              .                 .              .25720
    61   SIZXDP    EQ         .              .              .                 .              .25720
    62   SIZXDQ    EQ         .              .              .                 .              .25720
    63   EQ1DF     BS         .              .               NONE             .               .
    64   EQ1DG     BS         .              .               NONE             .               .
    65   EQ1DI     BS         .              .               NONE             .               .
    66   EQ1DJ     BS         .              .               NONE             .               .
    67   EQ1DL     BS         .              .               NONE             .               .
    68   EQ1DM     BS         .              .               NONE             .               .
    69   EQ1DP     BS         .              .               NONE             .               .
    70   EQ1DQ     BS         .              .               NONE             .               .
    71   EQ2DF     BS         .              .               NONE             .               .
    72   EQ2DG     BS         .              .               NONE             .               .
    73   EQ2DI     BS         .              .               NONE             .               .
    74   EQ2DJ     UL         .              .               NONE             .          2384.72727
    75   EQ2DL     BS         .              .               NONE             .               .
    76   EQ2DM     BS         .              .               NONE             .               .
    77   EQ2DP     BS         .              .               NONE             .               .
    78   EQ2DQ     BS         .              .               NONE             .               .
    79   EQ3DF     UL         .              .               NONE             .          2186.00000
    80   EQ3DG     UL         .              .               NONE             .          2186.00000
    81   EQ3DI     UL         .              .               NONE             .          2186.00000
    82   EQ3DJ     BS         .              .               NONE             .               .
    83   EQ3DL     UL         .              .               NONE             .          2186.00000
    84   EQ3DM     UL         .              .               NONE             .          2186.00000
    85   EQ3DP     UL         .              .               NONE             .          2186.00000
    86   EQ3DQ     UL         .              .               NONE             .          2186.00000
    87   EQ5DF     BS         .           1.00000            NONE          1.00000            .
    88   EQ5DG     BS         .           1.00000            NONE          1.00000            .
    89   EQ5DI     BS         .           1.00000            NONE          1.00000            .
    90   EQ5DJ     BS         .           1.00000            NONE          1.00000            .
    91   EQ5DL     BS         .           1.00000            NONE          1.00000            .
    92   EQ5DM     BS         .           1.00000            NONE          1.00000            .
    93   EQ5DP     BS         .           1.00000            NONE          1.00000            .
    94   EQ5DQ     BS         .           1.00000            NONE          1.00000            .
    95   EQ6DF     EQ         .              .              .                 .          2186.00000-
    96   EQ6DG     EQ         .              .              .                 .          2186.00000-
    97   EQ6DI     EQ         .              .              .                 .          2186.00000-
    98   EQ6DJ     EQ         .              .              .                 .          2384.72727-
    99   EQ6DL     EQ         .              .              .                 .          2186.00000-
   100   EQ6DM     EQ         .              .              .                 .          2186.00000-
   NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

      101  EQ6DP     EQ        .               .               .               .         2186.00000-
      102  EQ6DQ     EQ        .               .               .               .         2186.00000-
      103  HDF       EQ        .               .               .               .             .25720
      104  HDG       EQ        .               .               .               .             .25720
      105  HDI       EQ        .               .               .               .             .25720
      106  HDJ       EQ        .               .               .               .             .24214
      107  HDL       EQ        .               .               .               .             .25720
      108  HDM       EQ        .               .               .               .             .25720
      109  HDP       EQ        .               .               .               .             .00085
      110  HDQ       EQ        .               .               .               .             .00238
      111  JDF       EQ        .               .               .               .             .03150
      112  JDG       EQ        .               .               .               .             .02568-
      113  JDI       EQ        .               .               .               .             .00176-
      114  JDJ       EQ        .               .               .               .             .03150
      115  JDL       EQ        .               .               .               .             .03150
      116  JDM       EQ        .               .               .               .             .03150
      117  JDP       EQ        .               .               .               .             .03150
      118  JDQ       EQ        .               .               .               .             .03150
      119  SIZYDN    EQ        .               .               .               .            1.90000
      120  SIZYDP    EQ        .               .               .               .            1.90000
      121  SIZYMA    EQ        .               .               .               .            1.90000
      122  SIZYMB    EQ        .               .               .               .            1.90000
      123  SIZYMC    EQ        .               .               .               .            1.90000
      124  SIZYMD    EQ        .               .               .               .            1.90000
      125  SIZYPA    EQ        .               .               .               .            1.90138-
      126  SIZYPB    EQ        .               .               .               .            1.90000
 A    127  FQ03DN    EQ        .               .               .               .               .
 A    128  FQ03DP    EQ        .               .               .               .               .
 A    129  FQ03MA    EQ        .               .               .               .               .
 A    130  FQC3MB    EQ        .               .               .               .               .
 A    131  FQ03MC    EQ        .               .               .               .               .
 A    132  FQ03MC    EQ        .               .               .               .               .
      133  FQ03PA    EQ        .               .               .               .        27369.92598-
 A    134  FQ03PB    EQ        .               .               .               .               .
      135  FDN       EQ        .               .               .               .            1.90000
      136  FDP       EQ        .               .               .               .            1.90000
      137  FMA       EQ        .               .               .               .            1.90000
      138  FMB       EQ        .               .               .               .            1.90000
      139  FMC       EQ        .               .               .               .            1.90000
      140  FMD       EQ        .               .               .               .            1.90000
      141  FPA       EQ        .               .               .               .            1.90138-
      142  FPB       EQ        .               .               .               .            1.90000
```

```
SECTION 2 - COLUMNS

  NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

     145  WMCDA     BS      181.42359          .               .             NONE             .
     153  WMCDB     BS      126.17309          .               .             NONE             .
     232  WMBDL     BS     1385.04147          .               .             NONE             .
     252  WMFDN     BS     5505.52249          .               .             NONE             .
     255  WMADD     BS      252.59705          .               .             NONE             .
     266  WMDDP     BS      856.69138          .               .             NONE             .
     268  WMFDP     BS     1467.27484          .               .             NONE             .
     297  WSMCDG    BS          .              .               .             NONE             .
     305  WSMCDI    BS          .              .               .             NONE             .
     340  WSMFDP    BS          .              .               .             NONE             .
     509  XMGDNDA   BS      653.96005          .               .             NONE             .
     717  XMGDNDB   BS      454.80394          .               .             NONE             .
     938  XMDDPDC   BS      295.97757          .               .             NONE             .
     940  XMFDPDC   BS      506.92698          .               .             NONE             .
    1146  XMDDPDD   BS      462.73165          .               .             NONE             .
    1149  XMGDPDD   BS      391.04675          .               .             NONE             .
    1354  XMDDPDE   BS      566.28752          .               .             NONE             .
    1357  XMGDPDE   BS      478.56019          .               .             NONE             .
    1562  XMDDPDF   BS      593.91056          .               .             NONE             .
    1564  XMFDPDF   BS     1702.29243          .               .             NONE             .
    1770  XMDDPDG   BS     1498.96096          .               .             NONE             .
    1773  XMGDPDG   BS     1266.74719          .               .             NONE             .
    1978  XMDDPDH   BS     1500.69421          .               .             NONE             .
    1981  XMGDPDH   BS     1268.21193          .               .             NONE             .
    2186  XMDDPDI   BS      598.79141          .               .             NONE             .
    2189  XMGDPDI   BS      844.06173          .               .             NONE             .
    2394  XMDDPDJ   BS     1127.27236          .               .             NONE             .
    2396  XMFDPDJ   BS     1930.70424          .               .             NONE             .
    2588  XMFDNDK   BS     1592.47150          .               .             NONE             .
    2813  XMGDPDI   BS     2627.12441          .               .             NONE             .
    3018  XMDDPDM   BS      729.58253          .               .             NONE             .
    3021  XMGDPDM   BS      616.55861          .               .             NONE             .
    3437  XMGDPDO   BS      860.98712          .               .             NONE             .
    3858  XMDDPDQ   BS      525.76638          .               .             NONE             .
    3860  XMFDPDQ   BS      900.49219          .               .             NONE             .
    4066  XMDDPDR   BS      421.96560          .               .             NONE             .
    4069  XMGDPDR   BS      356.59604          .               .             NONE             .
    5732  XSMFDPDQ  BS          .              .               .             NONE             .
    5776  YMCMCDA   BS          .              .               .             NONE             .
    5881  YMDPADD   BS          .              .               .             NONE             .
    6591  SS1DF     BS          .              .               .             NONE             .
    6592  SS1DG     BS          .              .               .             NONE             .
    6593  SS1DI     BS          .              .               .             NONE             .
    6594  SS1DJ     BS          .              .               .             NONE             .
    6595  SS1DL     BS          .              .               .             NONE             .
    6596  SS1DM     BS          .              .               .             NONE             .
    6599  SS2DF     BS          .              .               .             NONE             .
    6602  SS2DJ     BS          .              .               .             NONE             .
    6603  SS2DL     BS          .              .               .             NONE             .
```

```
MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                          PAGE    19 -  74/168

  NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

     6604  SS2DM     BS         .               .               .             NONE            .
     6605  SS2DP     BS         .               .               .             NONE            .
     6606  SS2DQ     BS         .               .               .             NONE            .
     6607  S1DF      BS         .               .               .             NONE            .
     6609  S3DF      BS         .               .               .             NONE            .
     6610  S1DG      BS         .               .               .             NONE            .
     6612  S3DG      BS         .               .               .             NONE            .
     6613  S1DI      BS         .               .               .             NONE            .
     6615  S3DI      BS         .               .               .             NONE            .
     6616  S1DJ      BS         .               .               .             NONE            .
     6618  S3DJ      BS         .               .               .             NONE            .
     6619  S1DL      BS         .               .               .             NONE            .
     6621  S3DL      BS         .               .               .             NONE            .
     6622  S1DM      BS         .               .               .             NONE            .
     6624  S3DM      BS         .               .               .             NONE            .
     6625  S1DP      BS         .               .               .             NONE            .
     6627  S3DP      BS         .               .               .             NONE            .
     6628  S1DQ      BS         .               .               .             NONE            .
     6630  S3DQ      BS         .               .               .             NONE            .
     6631  CC1DN     BS         .               .               .             NONE            .
     6632  CC1DP     BS         .               .               .             NONE            .
     6633  CC1MA     BS         .               .               .             NONE            .
     6634  CC1MB     BS         .               .               .             NONE            .
     6635  CC1MC     BS         .               .               .             NONE            .
     6636  CC1MD     BS         .               .               .             NONE            .
     6637  CC1PA     BS         .               .               .             NONE            .
     6638  CC1PB     BS         .               .               .             NONE            .
     6639  C1DN      BS         .               .               .             NONE            .
     6641  C1DP      BS         .               .               .             NONE            .
     6643  C1MA      BS         .               .               .             NONE            .
     6645  C1MB      BS         .               .               .             NONE            .
     6647  C1MC      BS         .               .               .             NONE            .
     6649  C1MD      BS         .               .               .             NONE            .
     6651  C1PA      BS         .               .               .             NONE            .
     6653  C1PB      BS         .               .               .             NONE            .
     6666  QDL       BS         .               .               .             NONE            .
     6673  TPIT      BS   185501.72070       1.00000            .             NONE            .
     6674  TCRT      BS   188099.55741       1.00000            .             NONE            .
     6675  TASH      BS     3301.51418       1.00000            .             NONE            .
     6676  TSC1      BS         .            1.00000            .             NONE            .
     6677  TSC2      BS         .            1.00000            .             NONE            .
     6678  TWSH      BS         .            1.00000            .             NONE            .
     6680  TSTO      BS     7672.04582       1.00000            .             NONE            .
     6690  IN23DF    IV         .               .               .            1.00000          .
     6691  IN23DG    IV         .               .               .            1.00000          .
     6692  IN23DI    IV         .               .               .            1.00000          .
     6693  IN23DJ    IV         .               .               .            1.00000          .
     6694  IN23DL    IV         .               .               .            1.00000          .
     6695  IN23DM    IV         .               .               .            1.00000          .
     6696  IN23DP    IV         .               .               .            1.00000          .
     6697  IN23DQ    IV         .               .               .            1.00000          .
```

```
 NUMBER  .COLUMN.  AT   ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

   6698  IM12DN    IV          .               .               .           1.00000           .
   6699  IM12DP    IV          .               .               .           1.00000           .
   6700  IM12MA    IV          .               .               .           1.00000           .
   6701  IM12MB    IV          .               .               .           1.00000           .
   6702  IM12MC    IV          .               .               .           1.00000           .
   6703  IM12MD    IV          .               .               .           1.00000           .
   6705  IM12PB    IV          .               .               .           1.00000           .
```

Case 1: Spec. = 1.2 lb SO_2/MMBtu

```
MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                          PAGE    38  -  74/165
SECTION 1 - ROWS

NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

     1  COSTTOTL  BS    413844.04347    413844.04347-           NONE            NONE         1.00000
     2  COSTPIT   EQ          .               .                   .               .          1.00000
     3  COSTFRT   EQ          .               .                   .               .          1.00000
     4  COSTASH   EQ          .               .                   .               .          1.00000
     5  COSTSC1   EQ          .               .                   .               .          1.00000
     6  COSTSC2   EQ          .               .                   .               .          1.00000
     7  COSTWSH   EQ          .               .                   .               .          1.00000
     8  COSTREF   EQ          .               .                   .               .          8.37942-
     9  COSTSTO   EQ          .               .                   .               .          1.00000
    10  COSTBRN   EQ          .               .                   .               .           .00007
    11  AMA       BS        76.82088     49923.17912            NONE     50000.00000           .
    12  AMB       BS       363.64020     49636.35980            NONE     50000.00000           .
    13  AMC       BS        80.75896     49919.24104            NONE     50000.00000           .
    14  AMD       BS      1622.28924     48377.71076            NONE     50000.00000           .
    15  AME       BS          .          50000.00000            NONE     50000.00000           .
    16  AMF       BS     10193.04145     39806.95855            NONE     50000.00000           .
    17  AMG       BS     22914.55599     27085.44401            NONE     50000.00000           .
    18  AMH       BS          .          50000.00000            NONE     50000.00000           .
    19  DDA       EQ     18684.00000          .          18684.00000     18684.00000          .66753-
    20  DDB       EQ     12994.00000          .          12994.00000     12994.00000          .66753-
    21  DDC       EQ     17726.00000          .          17726.00000     17726.00000          .49585-
    22  DDD       EQ     20023.00000          .          20023.00000     20023.00000          .54416-
    23  DDE       EQ     24504.00000          .          24504.00000     24504.00000          .52313-
    24  DDF       EQ     59525.00000          .          59525.00000     59525.00000          .50792-
    25  DDG       EQ     64862.00000          .          64862.00000     64862.00000          .59738-
    26  DDH       EQ     64937.00000          .          64937.00000     64937.00000          .59738-
    27  DDI       EQ     43219.00000          .          43219.00000     43219.00000          .66978-
    28  DDJ       EQ     67512.00000          .          67512.00000     67512.00000          .50038-
    29  DDK       EQ     33461.00000          .          33461.00000     33461.00000          .53542-
    30  DDL       EQ     87017.00000          .          87017.00000     87017.00000          .68096-
    31  DDM       EQ     31570.00000          .          31570.00000     31570.00000          .66119-
    32  DDN       EQ    115682.00000          .         115682.00000    115682.00000          .42550-
    33  DDO       EQ     25608.00000          .          25608.00000     25608.00000          .58785-
    34  DDP       EQ     51307.00000          .          51307.00000     51307.00000          .46645-
    35  DDQ       EQ     31488.00000          .          31488.00000     31488.00000          .49158-
    36  DDR       EQ     18259.00000          .          18259.00000     18259.00000          .62192-
    37  EDA       UL     22420.79297          .                 NONE     22420.79297          .02391
    38  EDB       UL     15592.79688          .                 NONE     15592.79688          .02391
    39  EDC       UL     21271.19531          .                 NONE     21271.19531          .02300
    40  EDD       UL     24027.59375          .                 NONE     24027.59375          .02127
    41  EDE       UL     29404.79297          .                 NONE     29404.79297          .02109
    42  EDF       UL     71429.93750          .                 NONE     71429.93750          .02204
    43  EDG       UL     77834.37500          .                 NONE     77834.37500          .02174
    44  EDH       UL     77924.37500          .                 NONE     77924.37500          .02174
    45  EDI       UL     51862.78906          .                 NONE     51862.78906          .02237
    46  EDJ       UL     81014.37500          .                 NONE     81014.37500          .02264
    47  EDK       UL     40153.19141          .                 NONE     40153.19141          .02589
    48  EDL       UL    104420.37500          .                 NONE    104420.37500          .02505
    49  EDM       UL     37883.99219          .                 NONE     37883.99219          .02230
    NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

        50  EDN       UL   138818.37500         .             NONE   138818.37500         .03463
        51  EDO       UL    30729.59375         .             NONE    30729.59375         .02221
        52  EDP       UL    61568.38672         .             NONE    61568.38672         .02533
        53  EDQ       UL    37785.59375         .             NONE    37785.59375         .02334
        54  EDR       UL    21910.79297         .             NONE    21910.79297         .02195
        55  SIZXDF    EQ         .              .              .                .              .25720
        56  SIZXDG    EQ         .              .              .                .              .25720
        57  SIZXDI    EQ         .              .              .                .              .25720
        58  SIZXDJ    EQ         .              .              .                .              .24214
        59  SIZXDL    EQ         .              .              .                .              .25720
        60  SIZXDM    EQ         .              .              .                .              .25720
        61  SIZXDP    EQ         .              .              .                .              .25720
        62  SIZXDQ    EQ         .              .              .                .              .25720
        63  EQ1DF     BS         .              .             NONE         .              .
        64  EQ1DG     BS         .              .             NONE         .              .
        65  EQ1DI     BS         .              .             NONE         .              .
        66  EQ1DJ     BS         .              .             NONE         .              .
        67  EQ1DL     BS         .              .             NONE         .              .
        68  EQ1DM     BS         .              .             NONE         .              .
        69  EQ1DP     BS         .              .             NONE         .              .
        70  EQ1DQ     BS         .              .             NONE         .              .
        71  EQ2DF     BS         .              .             NONE         .              .
        72  EQ2DG     BS         .              .             NONE         .              .
        73  EQ2DI     BS         .              .             NONE         .              .
        74  EQ2DJ     UL         .              .             NONE         .          2384.72727
        75  EQ2DL     BS         .              .             NONE         .              .
        76  EQ2DM     BS         .              .             NONE         .              .
        77  EQ2DP     BS         .              .             NONE         .              .
        78  EQ2DQ     BS         .              .             NONE         .              .
        79  EQ3DF     UL         .              .             NONE         .          2186.00000
        80  EQ3DG     UL         .              .             NONE         .          2186.00000
        81  EQ3DI     UL         .              .             NONE         .          2186.00000
        82  EQ3DJ     BS         .              .             NONE         .              .
        83  EQ3DL     UL         .              .             NONE         .          2186.00000
        84  EQ3DM     UL         .              .             NONE         .          2186.00000
        85  EQ3DP     UL         .              .             NONE         .          2186.00000
        86  EQ3DQ     UL         .              .             NONE         .          2186.00000
        87  EQ5DF     BS         .             1.00000        NONE        1.00000         .
        88  EQ5DG     BS         .             1.00000        NONE        1.00000         .
        89  EQ5DI     BS         .             1.00000        NONE        1.00000         .
        90  EQ5DJ     BS         .             1.00000        NONE        1.00000         .
        91  EQ5DL     BS         .             1.00000        NONE        1.00000         .
        92  EQ5DM     BS         .             1.00000        NONE        1.00000         .
        93  EQ5DP     BS         .             1.00000        NONE        1.00000         .
        94  EQ5DQ     BS         .             1.00000        NONE        1.00000         .
        95  EQ6DF     EQ         .              .              .                .          2186.00000-
        96  EQ6DG     EQ         .              .              .                .          2186.00000-
        97  EQ6DI     EQ         .              .              .                .          2186.00000-
        98  EQ6DJ     EQ         .              .              .                .          2384.72727-
        99  EQ6DL     EQ         .              .              .                .          2186.00000-
       100  EQ6DM     EQ         .              .              .                .          2186.00000-
```

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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                          PAGE    40  -  74/165

  NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

       101  EQ6DP    EQ       .               .               .               .         2186.00000-
       102  EQ6DQ    EQ       .               .               .               .         2186.00000-
       103  HDF      EQ       .               .               .               .            .25720
       104  HDG      EQ       .               .               .               .            .25720
       105  HDI      EQ       .               .               .               .            .25720
       106  HDJ      EQ       .               .               .               .            .24214
       107  HDL      EQ       .               .               .               .            .25720
       108  HDM      EQ       .               .               .               .            .25720
       109  HDP      EQ       .               .               .               .            .01071
       110  HDQ      EQ       .               .               .               .            .00763
       111  JDF      EQ       .               .               .               .            .03150
       112  JDG      EQ       .               .               .               .            .02568-
       113  JDI      EQ       .               .               .               .            .00176-
       114  JDJ      EQ       .               .               .               .            .03150
       115  JDL      EQ       .               .               .               .            .03150
       116  JDM      EQ       .               .               .               .            .03150
       117  JDP      EQ       .               .               .               .            .03150
       118  JDQ      EQ       .               .               .               .            .03150
       119  SIZYDN   EQ       .               .               .               .           1.90000
       120  SIZYDP   EQ       .               .               .               .           1.90000
       121  SIZYMA   EQ       .               .               .               .           1.90000
       122  SIZYMB   EQ       .               .               .               .           1.90000
       123  SIZYMC   EQ       .               .               .               .           1.90000
       124  SIZYMD   EQ       .               .               .               .           1.90000
       125  SIZYPA   EQ       .               .               .               .           1.90138-
       126  SIZYPB   EQ       .               .               .               .           1.90000
  A    127  EQ03DN   EQ       .               .               .               .              .
  A    128  EQ03DP   EQ       .               .               .               .              .
  A    129  EQ03MA   EQ       .               .               .               .              .
  A    130  EQ03MB   EQ       .               .               .               .              .
  A    131  EQ03MC   EQ       .               .               .               .              .
  A    132  EQ03MD   EQ       .               .               .               .              .
       133  EQ03PA   EQ       .               .               .               .        27369.92598-
  A    134  EQ03PB   EQ       .               .               .               .              .
       135  FDN      EQ       .               .               .               .           1.90000
       136  FDP      EQ       .               .               .               .           1.90000
       137  FMA      EQ       .               .               .               .           1.90000
       138  FMB      EQ       .               .               .               .           1.90000
       139  FMC      EQ       .               .               .               .           1.90000
       140  FMD      EQ       .               .               .               .           1.90000
       141  FPA      EQ       .               .               .               .           1.90138-
       142  FPB      EQ       .               .               .               .           1.90000
```

```
SECTION 2 - COLUMNS

 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

    145  WMCDA     BS      47.63243          .               .              NONE            .
    153  WMCDB     BS      33.12652          .               .              NONE            .
    232  WMBDL     BS     363.64020          .               .              NONE            .
    252  WMFDN     BS    3130.20596          .               .              NONE            .
    253  WMGDN     BS    2177.58003          .               .              NONE            .
    255  WMADD     BS      76.82088          .               .              NONE            .
    268  WMFDP     BS    1388.30127          .               .              NONE            .
    269  WMGDP     BS     965.79509          .               .              NONE            .
    297  WSMCDG    BS          .             .               .              NONE            .
    305  WSMCDI    BS          .             .               .              NONE            .
    340  WSMFDP    BS          .             .               .              NONE            .
    509  XMGDNDA   BS     772.85439          .               .              NONE            .
    717  XMGDNDB   BS     537.49036          .               .              NONE            .
    940  XMFDPDC   BS     479.64270          .               .              NONE            .
    941  XMGDPDC   BS     333.67151          .               .              NONE            .
   1146  XMDDPDD   BS     121.48937          .               .              NONE            .
   1149  XMGDPDD   BS     746.90933          .               .              NONE            .
   1354  XMDDPDE   BS     148.67780          .               .              NONE            .
   1357  XMGDPDE   BS     914.06214          .               .              NONE            .
   1564  XMFDPDF   BS    1610.66787          .               .              NONE            .
   1565  XMGDPDF   BS    1120.49119          .               .              NONE            .
   1770  XMDDPDG   BS     393.54955          .               .              NONE            .
   1773  XMGDPDG   BS    2419.51926          .               .              NONE            .
   1978  XMDDPDH   BS     394.00461          .               .              NONE            .
   1981  XMGDPDH   BS    2422.31695          .               .              NONE            .
   2186  XMDDPDI   BS     262.23091          .               .              NONE            .
   2189  XMGDPDI   BS    1612.17970          .               .              NONE            .
   2396  XMFDPDJ   BS    1926.78737          .               .              NONE            .
   2397  XMGDPDJ   BS    1270.83580          .               .              NONE            .
   2588  XMFDNDK   BS     905.41152          .               .              NONE            .
   2589  XMGDNDK   BS     629.86472          .               .              NONE            .
   2813  XMGDPDL   BS    3489.52175          .               .              NONE            .
   3018  XMDDPDM   BS     191.55070          .               .              NONE            .
   3021  XMGDPDM   BS    1177.64208          .               .              NONE            .
   3437  XMGDPDO   BS    1049.98887          .               .              NONE            .
   3860  XMFDPDQ   BS     852.02476          .               .              NONE            .
   3861  XMGDPDQ   BS     592.72521          .               .              NONE            .
   4066  XMDDPDR   BS     110.78630          .               .              NONE            .
   4069  XMGDPDR   BS     681.10762          .               .              NONE            .
   5732  XSMFDPDQ  BS          .             .               .              NONE            .
   5776  YMCMCDA   BS          .             .               .              NONE            .
   5881  YMDPADD   BS          .             .               .              NONE            .
   6591  SS1DF     BS          .             .               .              NONE            .
   6592  SS1DG     BS          .             .               .              NONE            .
   6593  SS1DI     BS          .             .               .              NONE            .
   6594  SS1DJ     BS          .             .               .              NONE            .
   6595  SS1DL     BS          .             .               .              NONE            .
   6596  SS1DM     BS          .             .               .              NONE            .
   6599  SS2DF     BS          .             .               .              NONE            .
```

```
    NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

      6602  SS2DJ     BS          .               .               .                 NONE   .
      6603  SS2DL     BS          .               .               .                 NONE   .
      6604  SS2DM     BS          .               .               .                 NONE   .
      6605  SS2DP     BS          .               .               .                 NONE   .
      6606  SS2DO     BS          .               .               .                 NONE   .
      6607  S1DF      BS          .               .               .                 NONE   .
      6609  S3DF      BS          .               .               .                 NONE   .
      6610  S1DG      BS          .               .               .                 NONE   .
      6612  S3DG      BS          .               .               .                 NONE   .
      6613  S1DI      BS          .               .               .                 NONE   .
      6615  S3DI      BS          .               .               .                 NONE   .
      6616  S1DJ      BS          .               .               .                 NONE   .
      6618  S3DJ      BS          .               .               .                 NONE   .
      6619  S1DL      BS          .               .               .                 NONE   .
      6621  S3DL      BS          .               .               .                 NONE   .
      6622  S1DM      BS          .               .               .                 NONE   .
      6624  S3DM      BS          .               .               .                 NONE   .
      6625  S1DP      BS          .               .               .                 NONE   .
      6627  S3DP      BS          .               .               .                 NONE   .
      6628  S1DO      BS          .               .               .                 NONE   .
      6630  S3DO      BS          .               .               .                 NONE   .
      6631  CC1DN     BS          .               .               .                 NONE   .
      6632  CC1DP     BS          .               .               .                 NONE   .
      6633  CC1MA     BS          .               .               .                 NONE   .
      6634  CC1MB     BS          .               .               .                 NONE   .
      6635  CC1MC     BS          .               .               .                 NONE   .
      6636  CC1MD     BS          .               .               .                 NONE   .
      6637  CC1PA     BS          .               .               .                 NONE   .
      6638  CC1PB     BS          .               .               .                 NONE   .
      6639  C1DN      BS          .               .               .                 NONE   .
      6641  C1DP      BS          .               .               .                 NONE   .
      6643  C1MA      BS          .               .               .                 NONE   .
      6645  C1MB      BS          .               .               .                 NONE   .
      6647  C1MC      BS          .               .               .                 NONE   .
      6649  C1MD      BS          .               .               .                 NONE   .
      6651  C1PA      BS          .               .               .                 NONE   .
      6653  C1PB      BS          .               .               .                 NONE   .
      6666  QDL       BS          .               .               .                 NONE   .
      6673  TPIT      BS    171510.51717         1.00000          .                 NONE   .
      6674  TFRT      BS    232084.66238         1.00000          .                 NONE   .
      6675  TASH      BS      2128.46262         1.00000          .                 NONE   .
      6676  TSC1      BS          .              1.00000          .                 NONE   .
      6677  TSC2      BS          .              1.00000          .                 NONE   .
      6678  TWSH      BS          .              1.00000          .                 NONE   .
      6680  TSTO      BS      8120.40130         1.00000          .                 NONE   .
      6690  IN23DF    IV          .               .               .              1.00000   .
      6691  IN23DG    IV          .               .               .              1.00000   .
      6692  IN23DI    IV          .               .               .              1.00000   .
      6693  IN23DJ    IV          .               .               .              1.00000   .
      6694  IN23DL    IV          .               .               .              1.00000   .
      6695  IN23DM    IV          .               .               .              1.00000   .
```

```
MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                            PAGE    43  -  74/165

 NUMBER  .COLUMN.  AT   ...ACTIVITY...   ..INPUT COST..   ..LOWER LIMIT.   ..UPPER LIMIT.   .REDUCED COST.

    6696  IN23DP    IV          .                .                .             1.00000          .
    6697  IN23DQ    IV          .                .                .             1.00000          .
    6698  IM12DN    IV          .                .                .             1.00000          .
    6699  IM12DP    IV          .                .                .             1.00000          .
    6700  IM12MA    IV          .                .                .             1.00000          .
    6701  IM12MB    IV          .                .                .             1.00000          .
    6702  IM12MC    IV          .                .                .             1.00000          .
    6703  IM12MD    IV          .                .                .             1.00000          .
    6705  IM12PB    IV          .                .                .             1.00000          .
```

Case 2: Spec. = 20 lb SO_2/MMBtu

```
SECTION 1 - ROWS

NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

     1  COSTTOTL  BS   318475.25054    318475.25054-          NONE            NONE          1.00000
     2  COSTPIT   EQ         .               .                  .               .           1.00000
     3  COSTFRT   EQ         .               .                  .               .           1.00000
     4  COSTASH   EQ         .               .                  .               .           1.00000
     5  COSTSC1   EQ         .               .                  .               .              .
     6  COSTSC2   EQ         .               .                  .               .           1.00000
     7  COSTWSH   EQ         .               .                  .               .           1.00000
     8  COSTREF   EQ         .               .                  .               .          29.29178-
     9  COSTSTO   EQ         .               .                  .               .           1.00000
    10  COSTBRN   EQ         .               .                  .               .           1.00000
    11  AMA       BS     8650.43311     41349.56689           NONE      50000.00000            .
    12  AMB       BS         .          50000.00000           NONE      50000.00000            .
    13  AMC       BS     9499.41084     40500.58916           NCNE      50000.00000            .
    14  AMD       BS    11383.36038     38616.63962           NCNE      50000.00000            .
    15  AME       BS         .          50000.00000           NONE      50000.00000            .
    16  AMF       BS     7097.99399     42902.00601           NONE      50000.00000            .
    17  AMG       BS         .          50000.00000           NONE      50000.00000            .
    18  AMH       BS         .          50000.00000           NONE      50000.00000            .
    19  DDA       EQ    18684.00000          .         18684.00000      18684.00000          .34358-
    20  DDB       EQ    12994.00000          .         12994.00000      12994.00000          .34358-
    21  DDC       EQ    17726.00000          .         17726.00000      17726.00000          .38662-
    22  DDD       FQ    20023.00000          .         20023.00000      20023.00000          .43381-
    23  DDE       EQ    24504.00000          .         24504.00000      24504.00000          .41373-
    24  DDF       EQ    59525.00000          .         59525.00000      59525.00000          .39867-
    25  DDG       FQ    64862.00000          .         64862.00000      64862.00000          .47599-
    26  DDH       EQ    64937.00000          .         64937.00000      64937.00000          .47599-
    27  DDI       EQ    43219.00000          .         43219.00000      43219.00000          .39444-
    28  DDJ       EQ    67512.00000          .         67512.00000      67512.00000          .39114-
    29  DDK       EQ    33461.00000          .         33461.00000      33461.00000          .49105-
    30  DDL       EQ    87017.00000          .         87017.00000      87017.00000          .39307-
    31  DDM       EQ    31570.00000          .         31570.00000      31570.00000          .46043-
    32  DDN       EQ   115682.00000          .        115682.00000     115682.00000          .36617-
    33  DDO       EQ    25608.00000          .         25608.00000      25608.00000          .32676-
    34  DDP       EQ    51307.00000          .         51307.00000      51307.00000          .35725-
    35  DDQ       EQ    31488.00000          .         31488.00000      31488.00000          .38235-
    36  DDR       EQ    18259.00000          .         18259.00000      18259.00000          .36581-
    37  EDA       BS   253180.45174    120499.54826           NONE     373680.00000            .
    38  FDB       BS   176077.22061     83802.77939           NONE     259880.00000            .
    39  EDC       BS    91959.86293    262560.13707           NCNE     354520.00000            .
    40  EDD       BS   103876.35876    296583.64124           NONE     400460.00000            .
    41  FDE       BS   127123.12316    362956.87684           NCNE     490080.00000            .
    42  EDF       BS   308806.88485    881693.11514           NCNE    1190499.99999            .
    43  FDG       BS   762474.61583    534765.38416           NONE    1297239.99999            .
    44  FDH       BS   763356.26604    535383.73395           NONE    1298739.99999            .
    45  EDI       BS   585645.79019    278734.20981           NONE     864380.00000            .
    46  EDJ       BS   350242.25804    999997.74195           NCNE    1350239.99999            .
    47  EDK       BS    57328.97398    611891.02602           NONE     669220.00000            .
    48  EDL       BS  1179137.41006    561202.58994           NONE    1740340.00000            .
    49  EDM       BS   427794.20154    203605.79845           NONE     631400.00000            .
```

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   NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

        50  EDN       BS   198198.80960   2115441.19039            NONE   2313639.99999          .
        51  EDO       BS   301030.64910    211129.35089            NONE    512160.00000          .
        52  FDP       BS   266173.11787    759966.88213            NONE   1026140.00000          .
        53  EDQ       BS   163355.08089    466404.91910            NONE    629759.99999          .
        54  FDR       BS   214640.68346    150539.31654            NONE    365180.00000          .
   A    55  SIZXDF    EQ         .               .               .               .               .
   A    56  SIZXDG    EQ         .               .               .               .               .
   A    57  SIZXDI    EQ         .               .               .               .               .
   A    58  SIZXDJ    EQ         .               .               .               .               .
   A    59  SIZXDL    EQ         .               .               .               .               .
        60  SIZXDM    EQ         .               .               .               .               .18274-
   A    61  SIZXDP    EQ         .               .               .               .               .
   A    62  SIZXDQ    EQ         .               .               .               .               .
        63  EQ1DF     BS         .               .             NONE              .               .
   A    64  EQ1DG     UL         .               .             NONE              .               .
   A    65  EQ1DI     UL         .               .             NONE              .               .
   A    66  EQ1DJ     UL         .               .             NONE              .               .
   A    67  EQ1DL     UL         .               .             NONE              .               .
        68  EQ1DM     UL         .               .             NONE              .          14473.09965
   A    69  EQ1DP     UL         .               .             NONE              .               .
   A    70  EQ1DQ     UL         .               .             NONE              .               .
        71  EQ2DF     BS         .               .             NONE              .               .
        72  FQ2DG     BS         .               .             NONE              .               .
        73  FQ2DI     BS         .               .             NONE              .               .
        74  EQ2DJ     BS         .               .             NONE              .               .
        75  FQ2DL     BS         .               .             NONE              .               .
        76  EQ2DM     UL         .               .             NONE              .           2412.18328
        77  EQ2DP     BS         .               .             NONE              .               .
        78  EQ2DQ     BS         .               .             NONE              .               .
   A    79  EQ3DF     UL         .               .             NONE              .               .
        80  FQ3DG     BS         .               .             NONE              .               .
        81  EQ3DI     BS         .               .             NONE              .               .
        82  EQ3DJ     BS         .               .             NONE              .               .
        83  FQ3DL     BS         .               .             NONE              .               .
        84  FQ3DM     UL         .               .             NONE              .          14473.09965
   A    85  EQ3DP     UL         .               .             NONE              .               .
        86  FQ3DQ     BS         .               .             NONE              .               .
        87  FQ5DF     BS         .            1.00000          NONE           1.00000            .
        88  EQ5DG     BS         .            1.00000          NONE           1.00000            .
        89  EQ5DI     BS         .            1.00000          NONE           1.00000            .
        90  EQ5DJ     BS         .            1.00000          NONE           1.00000            .
        91  EQ5DL     BS         .            1.00000          NONE           1.00000            .
        92  EQ5DM     BS         .            1.00000          NONE           1.00000            .
        93  EQ5DP     BS         .            1.00000          NONE           1.00000            .
        94  EQ5DQ     BS         .            1.00000          NONE           1.00000            .
   A    95  FQ6DF     EQ         .               .               .               .               .
   A    96  EQ6DG     EQ         .               .               .               .               .
   A    97  EQ6DI     EQ         .               .               .               .               .
   A    98  EQ6DJ     EQ         .               .               .               .               .
   A    99  FQ6DL     EQ         .               .               .               .               .
       100  FQ6DM     EQ         .               .               .               .          16885.28293-
```

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.MPSX-PTF16.   EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 4                                        PAGE     41  -  74/212

 NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

 A   101  EQ6DP    EQ         .              .               .               .               .
 A   102  EQ6DQ    EQ         .              .               .               .               .
     103  HDF      EQ         .              .               .               .            .09765-
 A   104  HDG      EQ         .              .               .               .               .
 A   105  HDI      EQ         .              .               .               .               .
 A   106  HDJ      EQ         .              .               .               .               .
 A   107  HDL      EQ         .              .               .               .               .
     108  HDM      EQ         .              .               .               .            .18274-
 A   109  HDP      EQ         .              .               .               .               .
 A   110  HDQ      EQ         .              .               .               .               .
     111  JDF      EQ         .              .               .               .            .03150
 A   112  JDG      EQ         .              .               .               .               .
 A   113  JDI      EQ         .              .               .               .               .
 A   114  JDJ      EQ         .              .               .               .               .
 A   115  JDL      EQ         .              .               .               .               .
     116  JDM      EQ         .              .               .               .            .03150
     117  JDP      EQ         .              .               .               .            .03150
 A   118  JDQ      EQ         .              .               .               .               .
     119  SIZYDN   EQ         .              .               .               .            .38412-
     120  SIZYDP   EQ         .              .               .               .           1.90000
     121  SIZYMA   EQ         .              .               .               .           1.90000
     122  SIZYMB   EQ         .              .               .               .           1.90000
     123  SIZYMC   EQ         .              .               .               .           1.90000
     124  SIZYMD   EQ         .              .               .               .           1.90000
     125  SIZYPA   EQ         .              .               .               .           1.90000
     126  SIZYPB   EQ         .              .               .               .            .22675
 A   127  EQ03DN   EQ         .              .               .               .               .
 A   128  EQ03DP   EQ         .              .               .               .               .
 A   129  FQ03MA   EQ         .              .               .               .               .
 A   130  FQ03MB   EQ         .              .               .               .               .
 A   131  FQ03MC   EQ         .              .               .               .               .
 A   132  EQ03MD   EQ         .              .               .               .               .
 A   133  FQ03PA   EQ         .              .               .               .               .
 A   134  FQ03PB   EQ         .              .               .               .               .
     135  FDN      EQ         .              .               .               .            .38412-
     136  FDP      EQ         .              .               .               .           1.90000
     137  FMA      EQ         .              .               .               .           1.90000
     138  FMB      EQ         .              .               .               .           1.90000
     139  FMC      EQ         .              .               .               .           1.90000
     140  FMD      EQ         .              .               .               .           1.90000
     141  FPA      EQ         .              .               .               .           1.90000
     142  FPB      EQ         .              .               .               .            .22675
```

272

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SECTION 2 - COLUMNS

 NUMBER  .COLUMN.  AT   ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

    145  WMCDA     BS       917.32129         .               .             NONE            .
    153  WMCCB     BS       637.96151         .               .             NONE            .
    191  WMADG     BS      3230.82464         .               .             NONE            .
    199  WMADH     BS      3234.56045         .               .             NONE            .
    209  WMCDI     BS      2121.90691         .               .             NONE            .
    233  WMCDL     BS      4272.24077         .               .             NONE            .
    241  WMCDM     BS      1549.98036         .               .             NONE            .
    252  WMFDN     BS      5505.52249         .               .             NONE            .
    255  WMADQ     BS      1275.55360         .               .             NONE            .
    266  WMDDP     BS      2146.55740         .               .             NONE            .
    279  WMADR     BS       909.49442         .               .             NONE            .
    295  WSMADG    BS            .            .               .             NONE            .
    305  WSMCDI    BS            .            .               .             NONE            .
    321  WSMCDL    BS            .            .               .             NONE            .
    938  XMDDPDC   BS       741.61180         .               .             NONE            .
   1146  XMDDPDD   BS       837.71257         .               .             NONE            .
   1354  XMCDPDE   BS      1025.16548         .               .             NONE            .
   1562  XMDDPDF   BS      2490.37610         .               .             NONE            .
   2394  XMCDPDJ   BS      2824.53434         .               .             NONE            .
   2588  XMFDNDK   BS      1592.47150         .               .             NONE            .
   3858  XMDDPDQ   BS      1317.37968         .               .             NONE            .
   4266  XSMDDPDF  BS            .            .               .             NONE            .
   4890  XSMCDPDJ  BS            .            .               .             NONE            .
   5306  XSMCDPDM  BS            .            .               .             NONE            .
   5730  XSMDDPDQ  BS            .            .               .             NONE            .
   6162  YMDDNDK   BS            .            .               .             NONE            .
   6517  YSMDPBCF  BS            .            .               .             NONE            .
   6689  YSMAMADM  BS            .            .               .             NONE            .
   6800  SS1DG     BS            .            .               .             NONE            .
   6801  SS1DI     BS            .            .               .             NONE            .
   6802  SS1DJ     BS            .            .               .             NONE            .
   6803  SS1DL     BS            .            .               .             NONE            .
   6804  SS1DM     BS            .            .               .             NONE            .
   6805  SS1DP     BS            .            .               .             NONE            .
   6806  SS1DQ     BS            .            .               .             NONE            .
   6807  SS2DF     BS            .            .               .             NONE            .
   6812  SS2DM     BS            .            .               .             NONE            .
   6813  SS2DP     BS            .            .               .             NONE            .
   6815  S1DF      BS            .            .               .             NONE            .
   6816  S2CF      BS            .            .               .             NONE            .
   6819  S2DG      BS            .            .               .             NONE            .
   6822  S2DI      BS            .            .               .             NONE            .
   6825  S2DJ      BS            .            .               .             NONE            .
   6828  S2DL      BS            .            .               .             NONE            .
   6830  S1DM      BS            .            .               .             NONE            .
   6831  S2DM      BS            .            .               .             NONE            .
   6833  S1DP      BS            .            .               .             NONE            .
   6834  S2DP      BS            .            .               .             NONE            .
   6835  S3DP      BS            .            .               .             NONE            .
```

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.MPSX-PTF16.  EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 4                                           PAGE    43  -  74/212

 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

   6836  S1DQ      BS          .              .               .              NONE           .
   6837  S2DQ      BS          .              .               .              NONE           .
   6839  CC1DN     BS          .              .               .              NONE           .
   6840  CC1DP     BS          .              .               .              NONE           .
   6841  CC1MA     BS          .              .               .              NONE           .
   6842  CC1MB     BS          .              .               .              NONE           .
   6843  CC1MC     BS          .              .               .              NONE           .
   6844  CC1MD     BS          .              .               .              NONE           .
   6845  CC1PA     BS          .              .               .              NONE           .
   6846  CC1PB     BS          .              .               .              NONE           .
   6849  C1DP      BS          .              .               .              NONE           .
   6851  C1MA      BS          .              .               .              NONE           .
   6853  C1MB      BS          .              .               .              NONE           .
   6855  C1MC      BS          .              .               .              NONE           .
   6857  C1MD      BS          .              .               .              NONE           .
   6859  C1PA      BS          .              .               .              NONE           .
   6860  C2PA      BS          .              .               .              NONE           .
   6881  TPIT      BS    219516.61397        1.00000          .              NONE           .
   6882  TFRT      BS     90935.21831        1.00000          .              NONE           .
   6883  TASH      BS      4774.63592        1.00000          .              NONE           .
   6885  TSC2      BS          .             1.00000          .              NONE           .
   6886  TWSH      BS          .             1.00000          .              NONE           .
   6888  TSTO      BS      3248.78234        1.00000          .              NONE           .
   6889  TBRN      BS          .             1.00000          .              NONE           .
   6890  IN12DF    IV          .              .               .           1.00000           .
   6891  IN12DG    IV          .              .               .           1.00000           .
   6892  IN12DI    IV          .              .               .           1.00000           .
   6893  IN12DJ    IV          .              .               .           1.00000           .
   6894  IN12DL    IV          .              .               .           1.00000           .
   6895  IN12DM    IV          .              .               .           1.00000           .
   6898  IN23DF    IV          .              .               .           1.00000           .
   6899  IN23DG    IV          .              .               .           1.00000           .
   6900  IN23DI    IV          .              .               .           1.00000           .
   6901  IN23DJ    IV          .              .               .           1.00000           .
   6902  IN23DL    IV          .              .               .           1.00000           .
   6903  IN23DM    IV          .              .               .           1.00000           .
   6904  IN23DP    IV          .              .               .           1.00000           .
   6905  IN23DQ    IV          .              .               .           1.00000           .
   6906  IM12DN    IV          .              .               .           1.00000           .
   6907  IM12DP    IV          .              .               .           1.00000           .
   6908  IM12MA    IV          .              .               .           1.00000           .
   6909  IM12MB    IV          .              .               .           1.00000           .
   6910  IM12MC    IV          .              .               .           1.00000           .
   6911  IM12MD    IV          .              .               .           1.00000           .
   6913  IM12PA    IV          .              .               .           1.00000           .
```

Case 2: Spec. = 5 lb SO_2/MMBtu

```
SECTION 1 - ROWS

NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

    1  COSTTOTL  BS   358183.05216    358183.05216-        NONE            NONE          1.00000
    2  COSTPIT   EQ         .               .                .               .           1.00000
    3  COSTFRT   EQ         .               .                .               .           1.00000
    4  COSTASH   EQ         .               .                .               .           1.00000
    5  COSTSC1   EQ         .               .                .               .           1.00000
    6  COSTSC2   EQ         .               .                .               .            .91500
    7  COSTWSH   EQ         .               .                .               .            .74690
    8  COSTPFF   EQ         .               .                .               .           1.00000
    9  COSTSTO   EQ         .               .                .               .           1.00000
   10  COSTBRN   EQ         .               .                .               .            .00007
   11  AMA       BS      508.37364     49491.62636         NONE       50000.00000          .
   12  AMB       BS     2406.44351     47593.55649         NONE       50000.00000          .
   13  AMC       BS      534.43454     49465.56546         NONE       50000.00000          .
   14  AMD       BS    19741.47872     30258.52128         NONE       50000.00000          .
   15  AME       BS         .          50000.00000         NONE       50000.00000          .
   16  AMF       BS     7683.51512       316.48498         NONE        8000.00000          .
   17  AMG       BS     3813.71776      4186.28224         NONE        8000.00000          .
   18  AMH       BS         .               .              NONE            .                .
   19  DDA       EQ    18684.00000          .          18684.00000    18684.00000        .56753-
   20  DDB       EQ    12994.00000          .          12994.00000    12994.00000        .66753-
   21  DDC       EQ    17726.00000          .          17726.00000    17726.00000        .49084-
   22  DDD       EQ    20023.00000          .          20023.00000    20023.00000        .54416-
   23  DDE       EQ    24504.00000          .          24504.00000    24504.00000        .52313-
   24  DDF       EQ    59525.00000          .          59525.00000    59525.00000        .50541-
   25  DDG       EQ    64862.00000          .          64862.00000    64862.00000        .59736-
   26  DDH       EQ    64937.00000          .          64937.00000    64937.00000        .59738-
   27  DDI       EQ    43219.00000          .          43219.00000    43219.00000        .66970-
   28  DDJ       EQ    67512.00000          .          67512.00000    67512.00000        .49653-
   29  DDK       EQ    33461.00000          .          33461.00000    33461.00000        .49105-
   30  DDL       EQ    87017.00000          .          87017.00000    87017.00000        .60096-
   31  DDM       EQ    31570.00000          .          31570.00000    31570.00000        .60119-
   32  DDN       EQ   115682.00000          .         115682.00000   115682.00000        .50017-
   33  DDO       EQ    25608.00000          .          25608.00000    25608.00000        .50765-
   34  DDP       EQ    51307.00000          .          51307.00000    51307.00000        .45549-
   35  DDQ       EQ    31488.00000          .          31488.00000    31488.00000        .46574-
   36  DDR       EQ    18259.00000          .          18259.00000    18259.00000        .62192-
   37  EDA       UL    93420.00000          .              NONE       93420.00000        .02591
   38  EDB       UL    64970.00000          .              NONE       64970.00000        .02591
   39  EDC       UL    88630.00000          .              NONE       88630.00000        .02010
   40  EDD       UL   100115.00000          .              NONE      100115.00000        .02127
   41  EDE       UL   122520.00000          .              NONE      122520.00000        .02109
   42  EDF       UL   297625.00000          .              NONE      297625.00000        .02058
   43  EDG       UL   324310.00000          .              NONE      324310.00000        .02174
   44  EDH       UL   324685.00000          .              NONE      324685.00000        .02174
   45  EDI       UL   216095.00000          .              NONE      216095.00000        .02237
   46  EDJ       UL   337560.00000          .              NONE      337560.00000        .02028
   47  EDK       BS    57328.97398    109976.02602         NONE      167305.00000          .
   48  EDL       UL   435085.00000          .              NONE      435085.00000        .02505
   49  EDM       UL   157850.00000          .              NONE      157850.00000        .02230
```

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   NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

       50  EDN       BS  198198.80960    380211.19039        NONE        578410.00000          .
       51  EDO       UL  128040.00000          .             NONE        128040.00000        .02221
       52  EDP       UL  256535.00000          .             NONE        256535.00000        .01894
       53  EDQ       UL  157440.00000          .             NONE        157440.00000        .01993
       54  EDR       UL   91295.00000          .             NONE         91295.00000        .02195
       55  SIZXDF    EQ        .               .              .               .              .25720
       56  SIZXDG    EQ        .               .              .               .              .25720
       57  SIZXDI    EQ        .               .              .               .              .24214
       58  SIZXDJ    EQ        .               .              .               .              .24214
       59  SIZXDL    EQ        .               .              .               .              .07641
       60  SIZXDM    EQ        .               .              .               .              .24214
       61  SIZXDP    EQ        .               .              .               .              .17817
       62  SIZXDQ    EQ        .               .              .               .              .24214
       63  EQ1DF     BS        .               .             NONE             .                .
       64  EQ1DG     BS        .               .             NONE             .                .
       65  EQ1DI     BS        .               .             NONE             .                .
    A  66  EQ1DJ     UL        .               .             NONE             .                .
    A  67  EQ1DL     UL        .               .             NONE             .                .
    A  68  EQ1DM     UL        .               .             NONE             .                .
       69  EQ1DP     UL        .               .             NONE             .           9289.20000
    A  70  EQ1DQ     UL        .               .             NONE             .                .
       71  EQ2DF     BS        .               .             NONE             .                .
       72  EQ2DG     BS        .               .             NONE             .                .
       73  EQ2DI     UL        .               .             NONE             .           2384.72727
       74  EQ2DJ     UL        .               .             NONE             .           2384.72727
       75  EQ2DL     BS        .               .             NONE             .                .
       76  EQ2DM     UL        .               .             NONE             .           2384.72727
       77  EQ2DP     UL        .               .             NONE             .           3229.20000
       78  EQ2DQ     UL        .               .             NONE             .           2384.72727
       79  EQ3DF     UL        .               .             NONE             .           2186.00000
       80  EQ3DG     UL        .               .             NONE             .           2186.00000
       81  EQ3DI     BS        .               .             NONE             .                .
       82  EQ3DJ     BS        .               .             NONE             .                .
       83  EQ3DL     BS        .               .             NONE             .                .
       84  EQ3DM     BS        .               .             NONE             .                .
       85  EQ3DP     BS        .               .             NONE             .                .
       86  EQ3DQ     BS        .               .             NONE             .                .
       87  EQ5DF     BS        .            1.00000          NONE          1.00000             .
       88  EQ5DG     BS        .            1.00000          NONE          1.00000             .
       89  EQ5DI     BS        .            1.00000          NONE          1.00000             .
       90  EQ5DJ     BS        .            1.00000          NONE          1.00000             .
       91  EQ5DL     BS        .            1.00000          NONE          1.00000             .
       92  EQ5DM     BS        .            1.00000          NONE          1.00000             .
       93  EQ5DP     BS        .            1.00000          NONE          1.00000             .
       94  EQ5DQ     BS        .            1.00000          NONE          1.00000             .
       95  EQ6DF     EQ        .               .              .               .           2186.00000-
       96  EQ6DG     EQ        .               .              .               .           2186.00000-
       97  EQ6DI     EQ        .               .              .               .           2384.72727-
       98  EQ6DJ     EQ        .               .              .               .           2384.72727-
    A  99  EQ6DL     EQ        .               .              .               .                .
      100  EQ6DM     EQ        .               .              .               .           2384.72727-
```

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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                                              PAGE    20  -  74/164

    NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

       101  EQ6DP     EQ          .              .               .               .         12518.40000-
       102  EQ6DQ     EQ          .              .               .               .          2384.72727-
       103  HDF       EQ          .              .               .               .              .25720
       104  HDG       EQ          .              .               .               .              .25720
       105  HDI       EQ          .              .               .               .              .24214
       106  HDJ       EQ          .              .               .               .              .00533
       107  HDL       EQ          .              .               .               .              .07641
       108  HDM       EQ          .              .               .               .              .24214
       109  HDP       EQ          .              .               .               .              .17817
       110  HDQ       EQ          .              .               .               .              .00524
       111  JDF       EQ          .              .               .               .              .04617-
       112  JDG       EQ          .              .               .               .              .02682
       113  JDI       EQ          .              .               .               .              .00042
       114  JDJ       EQ          .              .               .               .              .02682
       115  JDL       EQ          .              .               .               .              .02682
       116  JDM       EQ          .              .               .               .              .01038-
       117  JDP       EQ          .              .               .               .              .02866-
       118  JDQ       EQ          .              .               .               .              .02833
       119  SIZYDN    EQ          .              .               .               .             1.41912
       120  SIZYDP    EQ          .              .               .               .             1.41912
       121  SIZYMA    EQ          .              .               .               .             1.41912
       122  SIZYMB    EQ          .              .               .               .             1.41912
       123  SIZYMC    EQ          .              .               .               .             1.41912
       124  SIZYMD    EQ          .              .               .               .             1.41912
       125  SIZYPA    EQ          .              .               .               .             1.41912
       126  SIZYPB    EQ          .              .               .               .             1.41912
A      127  EQ03DN    EQ          .              .               .               .                .
A      128  EQ03DP    EQ          .              .               .               .                .
A      129  EQ03MA    EQ          .              .               .               .                .
A      130  EQ03MB    EQ          .              .               .               .                .
A      131  EQ03MC    EQ          .              .               .               .                .
A      132  EQ03MD    EQ          .              .               .               .                .
A      133  EQ03PA    EQ          .              .               .               .                .
A      134  EQ03PB    EQ          .              .               .               .                .
       135  FDN       EQ          .              .               .               .             1.41912
       136  FDP       EQ          .              .               .               .             1.41912
       137  FMA       EQ          .              .               .               .             1.41912
       138  FMB       EQ          .              .               .               .             1.41912
       139  FMC       EQ          .              .               .               .             1.41912
       140  FMD       EQ          .              .               .               .             1.41912
       141  FPA       EQ          .              .               .               .             1.41912
       142  FPB       EQ          .              .               .               .             1.41912
```

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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                                  PAGE    21  -  74/164

SECTION 2 - COLUMNS

 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

     145  WMCDA     BS      315.21482          .               .           NONE            .
     153  WMCDB     BS      219.21972          .               .           NONE            .
     232  WMMDL     BS     2406.44351          .               .           NONE            .
     252  WMFDN     BS     5505.52249          .               .           NONE            .
     255  WMADD     BS      508.37364          .               .           NONE            .
     266  WMGDP     BS     2030.50337          .               .           NONE            .
     268  WMFDP     BS      132.01616          .               .           NONE            .
     305  WSMCDI    BS          .              .               .           NONE            .
     320  WSMMDL    BS          .              .               .           NONE            .
     329  WSMCDM    BS          .              .               .           NONE            .
     339  WSMFDP    BS          .              .               .           NONE            .
     509  XMGDNDA   BS      535.06565          .               .           NONE            .
     717  XMGDNDB   BS      372.11748          .               .           NONE            .
     938  XMDDPDC   BS      701.51642          .               .           NONE            .
     940  XMFDPDC   BS       45.61012          .               .           NONE            .
    1146  XMDDPDD   BS      803.97414          .               .           NONE            .
    1149  XMGDPDD   BS       35.18354          .               .           NONE            .
    1354  XMDDPDE   BS      983.89763          .               .           NONE            .
    1357  XMGDPDE   BS       43.05784          .               .           NONE            .
    1562  XMDDPDF   BS     2355.73534          .               .           NONE            .
    1564  XMFDPDF   BS      153.16159          .               .           NONE            .
    1770  XMDDPDG   BS     2604.37349          .               .           NONE            .
    1773  XMGDPDG   BS      113.97356          .               .           NONE            .
    1978  XMDDPDH   BS     2607.38493          .               .           NONE            .
    1981  XMGDPDH   BS      114.10575          .               .           NONE            .
    2186  XMDDPDI   BS     1735.35225          .               .           NONE            .
    2189  XMGDPDI   BS       75.94340          .               .           NONE            .
    2394  XMDDPDJ   BS     2671.82536          .               .           NONE            .
    2396  XMFDPDJ   BS      173.71265          .               .           NONE            .
    2588  XMFDNDK   BS     1592.47150          .               .           NONE            .
    2813  XMGDPDL   BS     1764.72641          .               .           NONE            .
    3018  XMDDPDM   BS     1267.61541          .               .           NONE            .
    3021  XMGDPDM   BS       55.47405          .               .           NONE            .
    3437  XMGDPDQ   BS      671.98501          .               .           NONE            .
    3858  XMDDPDQ   BS     1246.15530          .               .           NONE            .
    3860  XMFDPDQ   BS       81.02062          .               .           NONE            .
    4066  XMDDPDR   BS      733.14507          .               .           NONE            .
    4069  XMGDPDR   BS       32.08428          .               .           NONE            .
    4271  XSMADDDF  BS          .              .               .           NONE            .
    4890  XSMDDPDJ  BS          .              .               .           NONE            .
    4892  XSMFDPDJ  BS          .              .               .           NONE            .
    5730  XSMDDPDQ  BS          .              .               .           NONE            .
    5732  XSMFDPDQ  BS          .              .               .           NONE            .
    6215  YMBMMDL   BS          .              .               .           NONE            .
    6799  SS1DF     BS          .              .               .           NONE            .
    6800  SS1DG     BS          .              .               .           NONE            .
    6801  SS1DI     BS          .              .               .           NONE            .
    6803  SS1DL     BS          .              .               .           NONE            .
    6804  SS1DM     BS          .              .               .           NONE            .
```

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NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

   6805  SS1DP     BS          .               .               .            NONE            .
   6808  SS2DG     BS          .               .               .            NONE            .
   6810  SS2DJ     BS          .               .               .            NONE            .
   6811  SS2DL     BS          .               .               .            NONE            .
   6815  S1DF      BS          .               .               .            NONE            .
   6817  S3DF      BS          .               .               .            NONE            .
   6818  S1DG      BS          .               .               .            NONE            .
   6820  S3DG      BS          .               .               .            NONE            .
   6821  S1DI      BS          .               .               .            NONE            .
   6823  S3DI      BS          .               .               .            NONE            .
   6824  S1DJ      BS          .               .               .            NONE            .
   6826  S3DJ      BS          .               .               .            NONE            .
   6830  S1DM      BS          .               .               .            NONE            .
   6832  S3DM      BS          .               .               .            NONE            .
   6833  S1DP      BS          .               .               .            NONE            .
   6834  S2DP      BS          .               .               .            NONE            .
   6835  S3DP      BS          .               .               .            NONE            .
   6836  S1DO      BS          .               .               .            NONE            .
   6838  S3DO      BS          .               .               .            NONE            .
   6839  CC1DN     BS          .               .               .            NONE            .
   6840  CC1DP     BS          .               .               .            NONE            .
   6841  CC1MA     BS          .               .               .            NONE            .
   6842  CC1MB     BS          .               .               .            NONE            .
   6843  CC1MC     BS          .               .               .            NONE            .
   6844  CC1MD     BS          .               .               .            NONE            .
   6845  CC1PA     BS          .               .               .            NONE            .
   6846  CC1PB     BS          .               .               .            NONE            .
   6847  C1DN      BS          .               .               .            NONE            .
   6850  C2DP      BS          .               .               .            NONE            .
   6851  C1MA      BS          .               .               .            NONE            .
   6853  C1MB      BS          .               .               .            NONE            .
   6855  C1MC      BS          .               .               .            NONE            .
   6857  C1MD      BS          .               .               .            NONE            .
   6858  C2MD      BS          .               .               .            NONE            .
   6859  C1PA      BS          .               .               .            NONE            .
   6861  C1PB      BS          .               .               .            NONE            .
   6874  ODL       BS          .               .               .            NONE            .
   6881  TPIT      BS  205165.08274         1.00000            .            NONE            .
   6882  TFPT      BS  141748.93767         1.00000            .            NONE            .
   6883  TASH      BS    4197.03093         1.00000            .            NONE            .
   6884  TSC1      BS          .            1.00000            .            NONE            .
   6887  TFEF      BS          .            1.00000            .            NONE            .
   6888  TSTC      BS    7071.20087         1.00000            .            NONE            .
   6893  IN12DJ    IV          .               .               .         1.00000            .
   6894  IN12DL    IV          .               .               .         1.00000            .
   6895  IN12DM    IV          .               .               .         1.00000            .
   6896  IN12DP    IV          .               .               .         1.00000            .
   6897  IN12DG    IV          .               .               .         1.00000            .
   6898  IN23DF    IV          .               .               .         1.00000            .
   6899  IN23DG    IV          .               .               .         1.00000            .
   6900  IN23DI    IV          .               .               .         1.00000            .
```

```
MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                                      PAGE    23  -  74/164
  NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

    6901  IN23DJ    IV          .                .               .            1.00000           .
    6902  IN23DL    IV          .                .               .            1.00000           .
    6903  IN23DM    IV          .                .               .            1.00000           .
    6905  IN23DO    IV          .                .               .            1.00000           .
    6906  IM12DN    IV          .                .               .            1.00000           .
    6907  IM12DP    IV          .                .               .            1.00000           .
    6908  IM12MA    IV          .                .               .            1.00000           .
    6909  IM12MB    IV          .                .               .            1.00000           .
    6910  IM12MC    IV          .                .               .            1.00000           .
    6912  IM12PA    IV          .                .               .            1.00000           .
    6913  IM12PB    IV          .                .               .            1.00000           .
```

Case 2: Spec. = 3.1 lb SO_2/MMBtu

```
SECTION 1 - ROWS

NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

     1  COSTTOTL  BS  394608.00980    394608.00980-        NONE            NONE          1.00000
     2  COSTPIT   EQ        .               .               .               .            1.00000
     3  COSTFRT   EQ        .               .               .               .            1.00000
     4  COSTASH   EQ        .               .               .               .            1.00000
     5  COSTSC1   EQ        .               .               .               .            1.00000
     6  COSTSC2   EQ        .               .               .               .            1.00000
     7  COSTWSH   EQ        .               .               .               .            1.00000
     8  COSTREF   EQ        .               .               .               .            1.00000
     9  COSTSTO   EQ        .               .               .               .            1.00000
    10  COSTBRN   EQ        .               .               .               .             .00010
    11  AMA       BS        .          50000.00000         NONE        50000.00000          .
    12  AMB       BS     7489.45706    42510.54294         NONE        50000.00000          .
    13  AMC       BS        .          50000.00000         NONE        50000.00000          .
    14  AMD       BS    12940.42185    37059.57815         NONE        50000.00000          .
    15  AME       BS        .          50000.00000         NONE        50000.00000          .
    16  AMF       UL     8000.00000         .              NONE         8000.00000         4.72366
    17  AMG       UL     8000.00000         .              NONE         8000.00000         6.85261
    18  AMH       UL        .               .              NONE             .              2.66009
    19  DDA       EQ    18684.00000         .          18684.00000     18684.00000         1.00333-
    20  DDB       EQ    12994.00000         .          12994.00000     12994.00000         1.00333-
    21  DDC       EQ    17726.00000         .          17726.00000     17726.00000          .82655-
    22  DDD       EQ    20023.00000         .          20023.00000     20023.00000          .87670-
    23  DDE       EQ    24504.00000         .          24504.00000     24504.00000          .85567-
    24  DDF       EQ    59525.00000         .          59525.00000     59525.00000          .83989-
    25  DDG       EQ    64862.00000         .          64862.00000     64862.00000          .92992-
    26  DDH       EQ    64937.00000         .          64937.00000     64937.00000          .92992-
    27  DDI       EQ    43219.00000         .          43219.00000     43219.00000         1.00232-
    28  DDJ       EQ    67512.00000         .          67512.00000     67512.00000          .83200-
    29  DDK       EQ    33461.00000         .          33461.00000     33461.00000          .80926-
    30  DDL       EQ    87017.00000         .          87017.00000     87017.00000         1.02650-
    31  DDM       EQ    31570.00000         .          31570.00000     31570.00000          .99373-
    32  DDN       EQ   115682.00000         .         115682.00000    115682.00000          .67694-
    33  DDO       EQ    25608.00000         .          25608.00000     25608.00000          .92070-
    34  DDP       EQ    51307.00000         .          51307.00000     51307.00000          .79115-
    35  DDQ       EQ    31488.00000         .          31488.00000     31488.00000          .82141-
    36  DDR       EQ    18259.00000         .          18259.00000     18259.00000          .95446-
    37  EDA       UL    57920.38672         .              NONE        57920.38672          .09422
    38  EDB       UL    40281.39063         .              NONE        40281.39063          .09422
    39  EDC       UL    54950.58984         .              NONE        54950.58984          .08480
    40  EDD       UL    62071.28516         .              NONE        62071.28516          .08537
    41  EDE       UL    75962.37500         .              NONE        75962.37500          .08519
    42  EDF       UL   184527.43750         .              NONE       184527.43750          .08505
    43  EDG       UL   201072.12500         .              NONE       201072.12500          .08584
    44  EDH       UL   201304.62500         .              NONE       201304.62500          .08584
    45  EDI       UL   133978.87500         .              NONE       133978.87500          .08647
    46  EDJ       UL   209287.12500         .              NONE       209287.12500          .08498
    47  EDK       UL   103729.06250         .              NONE       103729.06250          .05452
    48  EDL       UL   269752.62500         .              NONE       269752.62500          .11398
    49  EDM       UL    97866.93750         .              NONE        97866.93750          .08640
```

293

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 NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

     50  EDN       UL   358514.12500         .              NONE        358614.12500         .05017
     51  EDO       UL    79384.75000         .              NONE         79384.75000         .08691
     52  EDP       UL   159051.62500         .              NONE        159051.62500         .08364
     53  EDQ       UL    97612.75000         .              NONE         97612.75000         .08463
     54  EDR       UL    56602.88672         .              NONE         56602.88672         .06605
     55  SIZXDF    EQ         .              .               .               .               .29944
     56  SIZXDG    EQ         .              .               .               .               .30513
     57  SIZXDI    EQ         .              .               .               .               .30609
     58  SIZXDJ    EQ         .              .               .               .               .29912
     59  SIZXDL    EQ         .              .               .               .               .33139
     60  SIZXDM    EQ         .              .               .               .               .30574
     61  SIZXDP    EQ         .              .               .               .               .29266
     62  SIZXDQ    EQ         .              .               .               .               .29750
     63  EQ1DF     BS         .              .              NONE             .                .
     64  EQ1DG     BS         .              .              NONE             .                .
     65  EQ1DI     BS         .              .              NONE             .                .
     66  EQ1DJ     BS         .              .              NONE             .                .
     67  EQ1DL     BS         .              .              NONE             .                .
     68  EQ1DM     BS         .              .              NONE             .                .
     69  EQ1DP     BS         .              .              NONE             .                .
     70  EQ1DQ     BS         .              .              NONE             .                .
     71  EQ2DF     BS         .              .              NONE             .                .
     72  EQ2DG     UL         .              .              NONE             .            2187.60303
     73  EQ2DI     UL         .              .              NONE             .            2383.24522
     74  EQ2DJ     BS         .              .              NONE             .                .
     75  EQ2DL     BS         .              .              NONE             .                .
     76  EQ2DM     BS         .              .              NONE             .                .
     77  EQ2DP     BS         .              .              NONE             .                .
     78  EQ2DQ     BS         .              .              NONE             .                .
     79  EQ3DF     UL         .              .              NONE             .            6376.02656
     80  EQ3DG     UL         .              .              NONE             .            8855.52667
     81  EQ3DI     UL         .              .              NONE             .            9285.93508
     82  EQ3DJ     UL         .              .              NONE             .            6350.44651
     83  EQ3DL     UL         .              .              NONE             .            8906.41799
     84  EQ3DM     UL         .              .              NONE             .            6874.83601
     85  EQ3DP     UL         .              .              NONE             .            5954.38114
     86  EQ3DQ     UL         .              .              NONE             .            6221.83697
     87  EQ5DF     BS         .           1.00000           NONE          1.00000             .
     88  EQ5DG     BS         .           1.00000           NONE          1.00000             .
     89  EQ5DI     BS         .           1.00000           NONE          1.00000             .
     90  EQ5DJ     BS         .           1.00000           NONE          1.00000             .
     91  EQ5DL     BS         .           1.00000           NONE          1.00000             .
     92  EQ5DM     BS         .           1.00000           NONE          1.00000             .
     93  EQ5DP     BS         .           1.00000           NONE          1.00000             .
     94  EQ5DQ     BS         .           1.00000           NONE          1.00000             .
     95  EQ6DF     EQ         .              .               .               .             316.02658
     96  EQ6DG     EQ         .              .               .               .            1579.67939-
     97  EQ6DI     EQ         .              .               .               .            1540.55130-
     98  EQ6DJ     EQ         .              .               .               .             290.44651
     99  EQ6DL     EQ         .              .               .               .            2846.41799
    100  EQ6DM     EQ         .              .               .               .             814.63801
    NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

       101  FQ6DP     EQ        .               .               .               .           205.61886-
       102  FQ6DQ     EQ        .               .               .               .           161.83697
       103  HDF       EQ        .               .               .               .              .29944
       104  HDG       EQ        .               .               .               .              .30313
       105  HDI       EQ        .               .               .               .              .30609
       106  HDJ       EQ        .               .               .               .              .29912
       107  HDL       EQ        .               .               .               .              .33139
       108  HDM       EQ        .               .               .               .              .30574
       109  HDP       EQ        .               .               .               .              .29266
       110  HDQ       EQ        .               .               .               .              .29750
       111  JDF       EQ        .               .               .               .              .03150
       112  JDG       EQ        .               .               .               .              .03150
       113  JDI       EQ        .               .               .               .              .03150
       114  JDJ       EQ        .               .               .               .              .03150
       115  JDL       EQ        .               .               .               .              .03150
       116  JDM       EQ        .               .               .               .              .03150
       117  JDP       EQ        .               .               .               .              .03150
       118  JDQ       EQ        .               .               .               .              .03150
       119  SIZYDN    EQ        .               .               .               .             1.90000
       120  SIZYDP    EQ        .               .               .               .             2.19549
       121  SIZYMA    EQ        .               .               .               .             1.90000
       122  SIZYMB    EQ        .               .               .               .             1.90000
       123  SIZYMC    EQ        .               .               .               .             1.90000
       124  SIZYMD    EQ        .               .               .               .             2.00651
       125  SIZYPA    EQ        .               .               .               .             1.90000
       126  SIZYPB    EQ        .               .               .               .             1.06417
  A    127  FQ03DN    EQ        .               .               .               .                .
       128  FQ03DP    EQ        .               .               .               .         70917.21936
  A    129  FQ03MA    EQ        .               .               .               .                .
  A    130  FQ03MB    EQ        .               .               .               .                .
  A    131  FQ03MC    EQ        .               .               .               .                .
       132  FQ03MD    EQ        .               .               .               .         25562.90860
  A    133  FQ03PA    EQ        .               .               .               .                .
       134  FQ03PB    EQ        .               .               .               .          5873.98266-
       135  FDN       EQ        .               .               .               .             1.90000
       136  FDP       EQ        .               .               .               .             2.19549
       137  FMA       EQ        .               .               .               .             1.90000
       138  FMB       EQ        .               .               .               .             1.90000
       139  FMC       EQ        .               .               .               .             1.90000
       140  FMD       EQ        .               .               .               .             2.00651
       141  FPA       EQ        .               .               .               .             1.90000
       142  FPB       EQ        .               .               .               .             1.06417
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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                      PAGE    25  -  74/164

SECTION 2 - COLUMNS

  NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

     250  WMDDN     BS      1931.58497         .               .              NONE            .
     252  WMFDN     BS      3308.26636         .               .              NONE            .
     254  WMHDN     BS           .             .               .              NONE            .
     266  WMDCP     BS       856.69138         .               .              NONE            .
     268  WMFDP     BS      1467.27484         .               .              NONE            .
     320  WSMBDL    BS           .             .               .              NONE            .
     338  WSMDDP    BS           .             .               .              NONE            .
     509  XMGDNDA   BS       125.32999         .               .              NONE            .
     717  XMGDNDB   BS        87.16216         .               .              NONE            .
     938  XMDDPDC   BS       295.97757         .               .              NONE            .
     940  XMFDPDC   BS       506.92698         .               .              NONE            .
    1146  XMCCPDD   BS       462.73165         .               .              NONE            .
    1149  XMGDPDD   BS       391.04675         .               .              NONE            .
    1354  XMDDPDE   BS       566.28752         .               .              NONE            .
    1357  XMGDPDE   BS       478.56019         .               .              NONE            .
    1562  XMDDPDF   BS      1375.62293         .               .              NONE            .
    1565  XMGDPDF   BS      1162.51616         .               .              NONE            .
    1770  XMDDPDG   BS      1498.96096         .               .              NONE            .
    1773  XMGDPDG   BS      1266.74719         .               .              NONE            .
    1978  XMDDPDH   BS      1500.69421         .               .              NONE            .
    1981  XMCDPDH   BS      1268.21193         .               .              NONE            .
    2156  XMDDPDI   BS       998.79141         .               .              NONE            .
    2189  XMGDPDI   BS       844.06173         .               .              NONE            .
    2394  XMDDPDJ   BS      1367.33320         .               .              NONE            .
    2396  XMFDPDJ   BS       860.12388         .               .              NONE            .
    2397  XMGDPDJ   BS       731.11232         .               .              NONE            .
    2586  XMDCNDK   BS       558.71045         .               .              NONE            .
    2588  XMFDNDK   BS       956.91573         .               .              NONE            .
    2813  XMGDPDL   BS       583.69958         .               .              NONE            .
    3018  XMDDPDM   BS       729.58253         .               .              NONE            .
    3021  XMGDPDM   BS       616.55861         .               .              NONE            .
    3437  XMGDPDO   BS       171.77579         .               .              NONE            .
    3858  XMDDPDQ   BS       525.76638         .               .              NONE            .
    3860  XMFDPDQ   BS       900.49219         .               .              NONE            .
    4066  XMDDPDR   BS       271.68670         .               .              NONE            .
    4069  XMGDPDR   BS       273.21761         .               .              NONE            .
    4256  XSMDDPDF  BS           .             .               .              NONE            .
    4474  XSMDDPDG  BS           .             .               .              NONE            .
    4682  XSMDDPDI  BS           .             .               .              NONE            .
    4890  XSMDDPDJ  BS           .             .               .              NONE            .
    5306  XSMDDPDM  BS           .             .               .              NONE            .
    5730  XSMDDPDQ  BS           .             .               .              NONE            .
    5775  YMBMBDA   BS       927.90241         .               .              NONE            .
    5815  YMBMBDB   BS       645.32027         .               .              NONE            .
    5917  YMDPBDD   BS           .             .               .              NONE            .
    6087  YMDDPDI   BS           .             .               .              NONE            .
    6215  YMBMBDL   BS      4321.52000         .               .              NONE            .
    6335  YMBMBDQ   BS      1271.76801         .               .              NONE            .
    6387  YMDMDDP   BS           .             .               .              NONE            .
```

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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                    PAGE    26  -  74/164

    NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

      6455  YMBMBCR   BS     322.94636          .               .            NONE            .
      6799  SS1DF     BS        .               .               .            NONE            .
      6800  SS1DG     BS        .               .               .            NONE            .
      6801  SS1DI     BS        .               .               .            NONE            .
      6802  SS1DJ     BS        .               .               .            NONE            .
      6803  SS1DL     BS        .               .               .            NONE            .
      6804  SS1DM     BS        .               .               .            NONE            .
      6805  SS1DP     BS        .               .               .            NONE            .
      6806  SS1DQ     BS        .               .               .            NONE            .
      6807  SS2DF     BS        .               .               .            NONE            .
      6808  SS2DG     BS        .               .               .            NONE            .
      6809  SS2DI     BS        .               .               .            NONE            .
      6810  SS2DJ     BS        .               .               .            NONE            .
      6811  SS2DL     BS        .               .               .            NONE            .
      6812  SS2DM     BS        .               .               .            NONE            .
      6813  SS2DP     BS        .               .               .            NONE            .
      6814  SS2DQ     BS        .               .               .            NONE            .
      6816  S2DF      BS        .               .               .            NONE            .
      6817  S3DF      BS        .               .               .            NONE            .
      6818  S1DG      BS        .               .               .            NONE            .
      6819  S2DG      BS        .               .               .            NONE            .
      6820  S3DG      BS        .               .               .            NONE            .
      6821  S1DI      BS        .               .               .            NONE            .
      6822  S2DI      BS        .               .               .            NONE            .
      6823  S3DI      BS        .               .               .            NONE            .
      6825  S2DJ      BS        .               .               .            NONE            .
      6826  S3DJ      BS        .               .               .            NONE            .
      6828  S2DL      BS        .               .               .            NONE            .
      6829  S3DL      BS        .               .               .            NONE            .
      6831  S2DM      BS        .               .               .            NONE            .
      6832  S3DM      BS        .               .               .            NONE            .
      6834  S2DP      BS        .               .               .            NONE            .
      6835  S3DP      BS        .               .               .            NONE            .
      6837  S2DQ      BS        .               .               .            NONE            .
      6838  S3DQ      BS        .               .               .            NONE            .
      6839  CC1DN     BS        .               .               .            NONE            .
      6840  CC1DP     BS        .               .               .            NONE            .
      6841  CC1MA     BS        .               .               .            NONE            .
      6842  CC1MB     BS    7489.45706          .               .            NONE            .
      6843  CC1MC     BS                        .               .            NONE            .
      6844  CC1MD     BS        .               .               .            NONE            .
      6845  CC1PA     BS        .               .               .            NONE            .
      6846  CC1PB     BS        .               .               .            NONE            .
      6847  C1DN      BS        .               .               .            NONE            .
      6850  C2DP      BS        .               .               .            NONE            .
      6851  C1MA      BS        .               .               .            NONE            .
      6853  C1MB      BS        .99876          .               .            NONE            .
      6854  C2MB      BS        .00124          .               .            NONE            .
      6855  C1MC      BS        .               .               .            NONE            .
      6858  C2MD      BS        .               .               .            NONE            .
      6859  C1PA      BS        .               .               .            NONE            .
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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                          PAGE    27  -  74/164

 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

    6861  C1PB      BS          .               .               .            NONE          .
    6874  ODL       BS          .               .               .            NONE          .
    6881  TPIT      BS   207109.93302      1.00000              .            NONE          .
    6882  TFRT      BS   160788.41117      1.00000              .            NONE          .
    6883  TASH      BS     3355.53245      1.00000              .            NONE          .
    6884  TSC1      BS          .           1.00000              .            NONE          .
    6885  TSC2      BS          .           1.00000              .            NONE          .
    6886  TWSH      BS    14229.96841      1.00000              .            NONE          .
    6887  TREF      BS      464.34634      1.00000              .            NONE          .
    6888  TSTO      BS     8659.81841      1.00000              .            NONE          .
    6906  IM12DN    IV          .               .               .          1.00000         .
    6908  IM12MA    IV          .               .               .          1.00000         .
 A  6909  IM12MB    IV        1.00000           .               .          1.00000         .
    6910  IM12MC    IV          .               .               .          1.00000         .
    6912  IM12PA    IV          .               .               .          1.00000         .
```

288

Case 2: Spec. = 1.2 lb SO_2/MMBtu

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SECTION 1 - ROWS

NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

     1  COSTTOTL  BS   525112.38300   525112.38300-         NONE            NONE          1.00000
     2  COSTPLT   EQ        .              .                 .               .             1.00000
     3  COSTFRT   EQ        .              .                 .               .             1.00000
     4  COSTASH   EQ        .              .                 .               .             1.00000
     5  COSTSC1   EQ        .              .                 .               .             1.00000
     6  COSTSC2   EQ        .              .                 .               .             1.00000
     7  COSTWSH   EQ        .              .                 .               .             1.00000
     8  COSTREF   EQ        .              .                 .               .             1.00000
     9  COSTSTO   EQ        .              .                 .               .             1.00000
    10  COSTBRN   EQ        .              .                 .               .              .00010
    11  AMA       BS        .         50000.00000           NONE       50000.00000            .
    12  AMB       BS     4171.04132   45828.95868           NONE       50000.00000            .
    13  AMC       BS        .         50000.00000           NONE       50000.00000            .
    14  AMD       BS    14902.69477   35097.30523           NONE       50000.00000            .
    15  AME       BS        .         50000.00000           NONE       50000.00000            .
    16  AMF       UL     8000.00000        .                NONE        8000.00000        4.36601
    17  AMG       UL     8000.00000        .                NONE        8000.00000        6.63264
    18  AMH       UL        .              .                NONE             .             2.26113
    19  DDA       EQ    18684.00000        .           18684.00000     18684.00000         .98854-
    20  DDB       EQ    12994.00000        .           12994.00000     12994.00000         .98854-
    21  DDC       EQ    17726.00000        .           17726.00000     17726.00000         .82114-
    22  DDD       EQ    20023.00000        .           20023.00000     20023.00000         .86839-
    23  DDE       EQ    24504.00000        .           24504.00000     24504.00000         .84828-
    24  DDF       EQ    59525.00000        .           59525.00000     59525.00000         .80715-
    25  DDG       EQ    64862.00000        .           64862.00000     64862.00000         .89309-
    26  DDH       EQ    64937.00000        .           64937.00000     64937.00000         .91924-
    27  DDI       EQ    43219.00000        .           43219.00000     43219.00000         .96220-
    28  DDJ       EQ    67512.00000        .           67512.00000     67512.00000         .79962-
    29  DDK       EQ    33461.00000        .           33461.00000     33461.00000         .86070-
    30  DDL       EQ    87017.00000        .           87017.00000     87017.00000         .86435-
    31  DDM       EQ    31570.00000        .           31570.00000     31570.00000         .95400-
    32  DDN       EQ   115682.00000        .          115682.00000    115682.00000         .75079-
    33  DDO       EQ    25608.00000        .           25608.00000     25608.00000         .90986-
    34  DDP       EQ    51307.00000        .           51307.00000     51307.00000         .76573-
    35  DDQ       EQ    31488.00000        .           31488.00000     31488.00000         .79084-
    36  DDR       EQ    18259.00000        .           18259.00000     18259.00000         .94379-
    37  FDA       UL    22420.79297        .                NONE       22420.79297         .08431
    38  FDB       UL    15592.79688        .                NONE       15592.79688         .08431
    39  FDC       UL    21271.19531        .                NONE       21271.19531         .09158
    40  FDD       UL    24027.59375        .                NONE       24027.59375         .08782
    41  FDE       UL    29404.79297        .                NONE       29404.79297         .08942
    42  FDF       UL    71429.93750        .                NONE       71429.93750         .07874
    43  FDG       UL    77834.37500        .                NONE       77834.37500         .07874
    44  FDH       UL    77924.37500        .                NONE       77924.37500         .08378
    45  FDI       UL    51862.78906        .                NONE       51862.78906         .07874
    46  FDJ       UL    81014.37500        .                NONE       81014.37500         .07874
    47  FDK       UL    40153.19141        .                NONE       40153.19141         .09448
    48  FDL       UL   104420.37500        .                NONE      104420.37500         .05807
    49  FDM       UL    37883.99219        .                NONE       37883.99219         .07874
```

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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                          PAGE    54  -  74/163

 NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

     50  EDN       UL   138818.37500         .               NONE     138818.37500          .10321
     51  EDG       UL    30729.59375         .               NONE      30729.59375          .08453
     52  EDP       UL    61568.38672         .               NONE      61568.38672          .07874
     53  EDQ       UL    37785.59375         .               NONE      37785.59375          .07874
     54  EDR       UL    21910.79297         .               NONE      21910.79297          .08399
     55  SIZXDF    EQ          .             .          .                 .                 .26998
     56  SIZXDG    EQ          .             .          .                 .                 .26998
     57  SIZXDI    EQ          .             .          .                 .                 .26998
     58  SIZXDJ    EQ          .             .          .                 .                 .26998
     59  SIZXDL    EQ          .             .          .                 .                 .21894
     60  SIZXDM    EQ          .             .          .                 .                 .26998
     61  SIZXDP    EQ          .             .          .                 .                 .26998
     62  SIZXDQ    EQ          .             .          .                 .                 .26998
     63  EQ1DF     BS        .57031-       .57031            NONE             .                  .
     64  EQ1DG     BS        .63937-       .63937            NONE             .                  .
     65  EQ1DI     BS        .35929-       .35929            NONE             .                  .
     66  EQ1DJ     BS        .67367-       .67367            NONE             .                  .
     67  EQ1DL     UL          .             .               NONE             .          6060.00000
     68  EQ1DM     BS        .20854-       .20854            NONE             .                  .
     69  EQ1DP     BS        .34693-       .34693            NONE             .                  .
     70  EQ1DQ     BS        .20748-       .20748            NONE             .                  .
     71  EQ2DF     BS        .42969-       .42969            NONE             .                  .
     72  EQ2DG     BS        .36063-       .36063            NONE             .                  .
     73  EQ2DI     BS        .64071-       .64071            NONE             .                  .
     74  EQ2DJ     BS        .32633-       .32633            NONE             .                  .
     75  EQ2DL     BS        .01917-       .01917            NONE             .                  .
     76  EQ2DM     BS        .79146-       .79146            NONE             .                  .
     77  EQ2DP     BS        .65307-       .65307            NONE             .                  .
     78  EQ2DQ     BS        .79252-       .79252            NONE             .                  .
     79  EQ3DF     UL          .             .               NONE             .          4042.80000
     80  EQ3DG     UL          .             .               NONE             .          4042.80000
     81  EQ3DI     UL          .             .               NONE             .          4042.80000
     82  EQ3DJ     UL          .             .               NONE             .          4042.80000
     83  EQ3DL     BS        .98083-       .98083            NONE             .                  .
     84  EQ3DM     UL          .             .               NONE             .          4042.80000
     85  EQ3DP     UL          .             .               NONE             .          4042.80000
     86  EQ3DQ     UL          .             .               NONE             .          4042.80000
     87  EQ5DF     BS       1.00000          .               NONE          1.00000               .
     88  EQ5DG     BS       1.00000          .               NONE          1.00000               .
     89  EQ5DI     BS       1.00000          .               NONE          1.00000               .
     90  EQ5DJ     BS       1.00000          .               NONE          1.00000               .
     91  EQ5DL     BS       1.00000          .               NONE          1.00000               .
     92  EQ5DM     BS       1.00000          .               NONE          1.00000               .
     93  EQ5DP     BS       1.00000          .               NONE          1.00000               .
     94  EQ5DQ     BS       1.00000          .               NONE          1.00000               .
     95  EQ6DF     EQ          .             .          .                 .          2017.20000-
     96  EQ6DG     EQ          .             .          .                 .          2017.20000-
     97  EQ6DI     EQ          .             .          .                 .          2017.20000-
     98  EQ6DJ     EQ          .             .          .                 .          2017.20000-
     99  EQ6DL     EQ          .             .          .                 .          6060.00000-
    100  EQ6DM     EQ          .             .          .                 .          2017.20000-
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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                    PAGE    55  -  74/163

  NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

      101  F06CP     EQ        .               .               .               .          2017.20000-
      102  F06CQ     EQ        .               .               .               .          2017.20000-
      103  HDF       EQ        .               .               .               .              .26998
      104  HDG       EQ        .               .               .               .              .26998
      105  HDI       EQ        .               .               .               .              .26998
      106  HDJ       EQ        .               .               .               .              .26998
      107  HDL       EQ        .               .               .               .              .21894
      108  HDM       EQ        .               .               .               .              .26998
      109  HDP       EQ        .               .               .               .              .26998
      110  HDQ       EQ        .               .               .               .              .26998
      111  JDF       EQ        .               .               .               .              .03150
      112  JDG       EQ        .               .               .               .              .03150
      113  JDI       EQ        .               .               .               .              .03150
      114  JDJ       EQ        .               .               .               .              .03150
      115  JDL       EQ        .               .               .               .              .03150
      116  JDM       EQ        .               .               .               .              .03150
      117  JDP       EQ        .               .               .               .              .03150
      118  JDQ       EQ        .               .               .               .              .03150
      119  SIZYDN    EQ        .               .               .               .             1.90000
      120  SIZYDP    EQ        .               .               .               .             2.05640
      121  SIZYMA    EQ        .               .               .               .             1.90000
      122  SIZYMB    EQ        .               .               .               .             2.53627
      123  SIZYMC    EQ        .               .               .               .             1.90000
      124  SIZYMD    EQ        .               .               .               .             1.90000
      125  SIZYPA    EQ        .               .               .               .             1.90000
      126  SIZYPB    EQ        .               .               .               .             1.90000
  A   127  F003CN    EQ        .               .               .               .                .
      128  F003DP    EQ        .               .               .               .         37535.61611
  A   129  F003MA    EQ        .               .               .               .                .
      130  F003MB    EQ        .               .               .               .        152703.69041
  A   131  F003MC    EQ        .               .               .               .                .
  A   132  F003MD    EQ        .               .               .               .                .
  A   133  F003PA    EQ        .               .               .               .                .
  A   134  F003PB    EQ        .               .               .               .                .
      135  FDN       EQ        .               .               .               .             1.90000
      136  FDP       EQ        .               .               .               .             2.05640
      137  FMA       EQ        .               .               .               .             1.90000
      138  FMB       EQ        .               .               .               .             2.53627
      139  FMC       EQ        .               .               .               .             1.90000
      140  FMD       EQ        .               .               .               .             1.90000
      141  FPA       EQ        .               .               .               .             1.90000
      142  FPB       EQ        .               .               .               .             1.90000
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SECTION 2 - COLUMNS

 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

     252  WMFDN     BS     3130.20596          .               .             NONE             .
     253  WMGDN     BS     2177.58003          .               .             NONE             .
     254  WMHDN     BS          .              .               .             NONE             .
     266  WMDDP     BS      202.08412          .               .             NONE             .
     268  WMFDP     BS      493.97842          .               .             NONE             .
     320  WSMBDL    BS     4171.04132          .               .             NONE             .
     338  WSMDDG    BS     1510.22200          .               .             NONE             .
     508  XMFDNDA   BS      505.56486          .               .             NONE             .
     509  XMGDNDA   BS      351.70483          .               .             NONE             .
     716  XMFDNDB   BS      351.60090          .               .             NONE             .
     717  XMGDNDB   BS      244.59705          .               .             NONE             .
     940  XMFDPDC   BS      479.64270          .               .             NONE             .
     941  XMGDPDC   BS      333.67151          .               .             NONE             .
    1148  XMFDPDD   BS      541.79652          .               .             NONE             .
    1149  XMGDPDD   BS      376.90992          .               .             NONE             .
    1356  XMFDPDE   BS      663.04662          .               .             NONE             .
    1357  XMGDPDE   BS      461.25956          .               .             NONE             .
    1562  XMDDPDF   BS      363.34477          .               .             NONE             .
    1770  XMDDPDG   BS      395.92258          .               .             NONE             .
    1978  XMDDPDH   BS      341.12275          .               .             NONE             .
    1980  XMFDPDH   BS      235.83302          .               .             NONE             .
    1981  XMGDPDH   BS     2261.26372          .               .             NONE             .
    2185  XMDDPDI   BS      263.81211          .               .             NONE             .
    2394  XMDDPDJ   BS      412.09839          .               .             NONE             .
    2598  XMFDNDK   BS      905.41152          .               .             NONE             .
    2599  XMGDNDK   BS      629.86472          .               .             NONE             .
    2810  XMDDPDL   BS      263.53661          .               .             NONE             .
    3018  XMDDPDM   BS      192.70572          .               .             NONE             .
    3436  XMFDPDO   BS      692.91948          .               .             NONE             .
    3437  XMGDPDO   BS      482.04105          .               .             NONE             .
    3858  XMDDPDQ   BS      192.20520          .               .             NONE             .
    4066  XMFDPDR   BS      110.78630          .               .             NONE             .
    4069  XMGDPDR   BS      681.10762          .               .             NONE             .
    4266  XSMDDPDF  BS     2127.03333          .               .             NONE             .
    4474  XSMDDPDG  BS     2317.74234          .               .             NONE             .
    4682  XSMDDPDI  BS     1544.36346          .               .             NONE             .
    4890  XSMDDPDJ  BS     2412.43195          .               .             NONE             .
    5306  XSMDDPDM  BS     1128.10464          .               .             NONE             .
    5730  XSMDDPDQ  BS     1125.17448          .               .             NONE             .
    6215  YMBMBDL   BS          .              .               .             NONE             .
    6447  YMDDPDR   BS          .              .               .             NONE             .
    6799  SS1DF     BS    50840.33578          .               .             NONE             .
    6800  SS1DG     BS    55398.66123          .               .             NONE             .
    6801  SS1DI     BS    36513.36469          .               .             NONE             .
    6802  SS1DJ     BS    57662.02712          .               .             NONE             .
    6803  SS1DL     BS    80717.94983          .               .             NONE             .
    6804  SS1DM     BS    26963.94922          .               .             NONE             .
    6805  SS1DP     BS    36097.31574          .               .             NONE             .
    6806  SS1DQ     BS    26893.91266          .               .             NONE             .
```

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NUMBER  .COLUMN.  AT   ...ACTIVITY...   ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

  6807  SS2DF     BS    157604.90628         .               .             NONE              .
  6808  SS2DG     BS    1[illegible]1735.70311         .               .             NONE              .
  6809  SS2DI     BS    1[illegible]4431.33277         .               .             NONE              .
  6810  SS2DJ     BS    178752.13136         .               .             NONE              .
  6811  SS2DL     BS    347087.01326         .               .             NONE              .
  6812  SS2DM     BS     83588.17118         .               .             NONE              .
  6813  SS2DP     BS    111901.58321         .               .             NONE              .
  6814  SS2DQ     BS     83371.05803         .               .             NONE              .
  6815  S1DF      BS          .42969         .               .             NONE              .
  6816  S2DF      BS          .57031         .               .             NONE              .
  6817  S3DF      BS          .              .               .             NONE              .
  6818  S1DG      BS          .36063         .               .             NONE              .
  6819  S2DG      BS          .63937         .               .             NONE              .
  6820  S3DG      BS          .              .               .             NONE              .
  6821  S1DI      BS          .64071         .               .             NONE              .
  6822  S2DI      BS          .35929         .               .             NONE              .
  6823  S3DI      BS          .              .               .             NONE              .
  6824  S1DJ      BS          .32633         .               .             NONE              .
  6825  S2DJ      BS          .67367         .               .             NONE              .
  6826  S3DJ      BS          .              .               .             NONE              .
  6828  S2DL      BS          .98083         .               .             NONE              .
  6829  S3DL      BS          .01917         .               .             NONE              .
  6830  S1DM      BS          .79146         .               .             NONE              .
  6831  S2DM      BS          .20854         .               .             NONE              .
  6832  S3DM      BS          .              .               .             NONE              .
  6833  S1DP      BS          .65307         .               .             NONE              .
  6834  S2DP      BS          .34693         .               .             NONE              .
  6835  S3DP      BS          .              .               .             NONE              .
  6836  S1DQ      BS          .79252         .               .             NONE              .
  6837  S2DQ      BS          .20748         .               .             NONE              .
  6838  S3DQ      BS          .              .               .             NONE              .
  6839  CC1DN     BS          .              .               .             NONE              .
  6840  CC1DP     BS          .              .               .             NONE              .
  6841  CC1MA     BS          .              .               .             NONE              .
  6842  CC1MB     BS          .              .               .             NONE              .
  6843  CC1MC     BS          .              .               .             NONE              .
  6844  CC1MD     BS          .              .               .             NONE              .
  6845  CC1PA     BS          .              .               .             NONE              .
  6846  CC1PB     BS          .              .               .             NONE              .
  6847  C1DN      BS          .              .               .             NONE              .
  6850  C2DP      BS          .              .               .             NONE              .
  6851  C1MA      BS          .              .               .             NONE              .
  6854  C2MB      BS          .              .               .             NONE              .
  6855  C1MC      BS          .              .               .             NONE              .
  6857  C1MD      BS          .              .               .             NONE              .
  6858  C2MD      BS          .              .               .             NONE              .
  6859  C1PA      BS          .              .               .             NONE              .
  6861  C1PB      BS          .              .               .             NONE              .
  6863  OCA       BS          .              .               .             NONE              .
  6831  TPIT      BS    199517.06321      1.00000            .             NONE              .
  6832  TFRT      BS    159133.35653      1.00000            .             NONE              .
```

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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                         PAGE    58  -  74/163

  NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

    6883  TASH      BS     3762.39481       1.00000           .              NONE              .
    6884  TSC1      BS   116356.11636       1.00000           .              NONE              .
    6885  TSC2      BS    39326.86482       1.00000           .              NONE              .
    6886  TWSH      BS          .           1.00000           .              NONE              .
    6887  TREF      BS          .           1.00000           .              NONE              .
    6888  TSTO      BS     7016.58727       1.00000           .              NONE              .
    6890  IN12DF    IV        1.00000           .             .            1.00000       2017.20000
    6891  IN12DG    IV        1.00000           .             .            1.00000       2017.20000
    6892  IN12DI    IV        1.00000           .             .            1.00000       2017.20000
    6893  IN12DJ    IV        1.00000           .             .            1.00000       2017.20000
    6894  IN12DL    IV          .               .             .            1.00000           .
    6895  IN12DM    IV        1.00000           .             .            1.00000       2017.20000
    6896  IN12DP    IV        1.00000           .             .            1.00000       2017.20000
    6897  IN12DQ    IV        1.00000           .             .            1.00000       2017.20000
    6902  IN23DL    IV        1.00000           .             .            1.00000       6060.00000
    6906  IM12DN    IV          .               .             .            1.00000           .
    6908  IM12MA    IV          .               .             .            1.00000           .
    6910  IM12MC    IV          .               .             .            1.00000           .
    6912  IM12PA    IV          .               .             .            1.00000           .
    6913  IM12PB    IV          .               .             .            1.00000           .
```

Case 3: Spec. = 20 lb SO_2/MMBtu

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MPSX-PTF13    EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                      PAGE   18  - ,74/183
SECTION 1 - ROWS

  NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

      1   COSTTOTL  BS   326595.26326    326595.26326-          NONE            NONE       1.00000
      2   COSTPIT   EQ        .                .                .               .          1.00000
      3   COSTFRT   EQ        .                .                .               .          1.00000
      4   COSTASH   EQ        .                .                .               .          1.00000
      5   COSTSC1   EQ        .                .                .               .          1.00000
1A    6   COSTSC2   EQ        .                .                .               .           .
      7   COSTWSH   EQ        .                .                .               .           .41412-
      8   COSTPFF   EQ        .                .                .               .          1.00000
      9   COSTSTO   EQ        .                .                .               .          1.00000
     10   COSTBRN   EQ        .                .                .               .          1.00000
     11   AMA       BS    11258.37960     38741.62040           NONE      50000.00000        .
     12   AMB       BS        .           50000.00000           NONE      50000.00000        .
     13   AMC       BS    11142.23291     38857.76709           NONE      50000.00000        .
     14   AMD       UL     7000.00000          .                NONE       7000.00000       2.30198
     15   AME       UL        .                .                NONE            .          1.68674
     16   AMF       UL     8000.00000          .                NONE       8000.00000        .54325
     17   AMG       BS        .            8000.00000           NONE       8000.00000        .
     18   AMH       BS        .                .                NONE            .           .
     19   DDA       EQ    18684.00000          .         18684.00000     18684.00000        .34358-
     20   DDB       EQ    12994.00000          .         12994.00000     12994.00000        .34358-
     21   DDC       EQ    17726.00000          .         17726.00000     17726.00000        .48157-
     22   DDD       EQ    20023.00000          .         20023.00000     20023.00000        .53012-
     23   DDE       EQ    24504.00000          .         24504.00000     24504.00000        .51004-
     24   DDF       EQ    59525.00000          .         59525.00000     59525.00000        .49498-
     25   DDG       EQ    64862.00000          .         64862.00000     64862.00000        .47599-
     26   DDH       EQ    64937.00000          .         64937.00000     64937.00000        .47599-
     27   DDI       EQ    43219.00000          .         43219.00000     43219.00000        .39444-
     28   DDJ       EQ    67512.00000          .         67512.00000     67512.00000        .48745-
     29   DDK       EQ    33461.00000          .         33461.00000     33461.00000        .49617-
     30   DDL       EQ    87017.00000          .         87017.00000     87017.00000        .39307-
     31   DDM       EQ    31570.00000          .         31570.00000     31570.00000        .46043-
     32   DDN       EQ   115682.00000          .        115682.00000    115682.00000        .39203-
     33   DDO       EQ    25608.00000          .         25608.00000     25608.00000        .32676-
     34   DDP       EQ    51307.00000          .         51307.00000     51307.00000        .44890-
     35   DDQ       EQ    31488.00000          .         31488.00000     31488.00000        .46204-
     36   DDR       EQ    18259.00000          .         18259.00000     18259.00000        .36581-
     37   FDA       BS   253180.43174    120499.54826           NONE     373680.00000        .
     38   FDB       BS   176077.22061     83802.77939           NONE     259880.00000        .
     39   FDC       BS   208375.08927    146144.91073           NONE     354520.00000        .
     40   FDD       BS   103876.35876    296583.64124           NONE     400460.00000        .
     41   FDE       BS   127123.12316    362956.87684           NONE     490080.00000        .
     42   FDF       BS   308806.88485    881693.11514           NONE    1190499.99999        .
     43   FDG       BS   762474.61583    534765.38416           NONE    1297239.99999        .
     44   FDH       BS   763356.26604    535383.73395           NONE    1298739.99999        .
     45   FDI       BS   585645.79019    278734.20981           NONE     864380.00000        .
     46   FDJ       BS   367038.42438    983201.57561           NONE    1350239.99999        .
     47   FDK       BS   453418.49153    215801.50847           NONE     669220.00000        .
     48   FDL       BS  1179137.41005    561202.58994           NONE    1740340.00000        .
     49   FDM       BS   427794.20154    203605.79845           NONE     631400.00000        .
  NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

      50  FDN       BS   198198.80960   2115441.19039          NONE   2313639.99999         .
      51  FDO       BS   301030.64910    211129.35089          NONE    512160.00000         .
      52  FDP       BS    87904.65521    938235.34478          NONE   1026140.00000         .
      53  FDQ       BS   370152.02589    259607.97411          NONE    629759.99999         .
      54  FDR       BS   214640.68346    150539.31654          NONE    365180.00000         .
      55  SIZXDF    EQ         .               .              .               .         .25720
      56  SIZXDG    EQ         .               .              .               .         .25720
      57  SIZXDI    EQ         .               .              .               .         .25720
A     58  SIZXDJ    EQ         .               .              .               .           .
      59  SIZXDL    EQ         .               .              .               .         .25720
      60  SIZXDM    EQ         .               .              .               .         .24214
      61  SIZXDP    EQ         .               .              .               .         .25720
      62  SIZXDQ    EQ         .               .              .               .         .24214
      63  EQ1DF     BS         .               .             NONE             .           .
A     64  EQ1DG     UL         .               .             NONE             .           .
A     65  EQ1DI     UL         .               .             NONE             .           .
      66  EQ1DJ     BS         .               .             NONE             .           .
      67  EQ1DL     UL         .               .             NONE             .      3030.00000
      68  EQ1DM     BS         .               .             NONE             .           .
      69  EQ1DP     BS         .               .             NONE             .           .
      70  EQ1DQ     UL         .               .             NONE             .      4222.36364
      71  EQ2DF     BS         .               .             NONE             .           .
      72  EQ2DG     BS         .               .             NONE             .           .
      73  EQ2DI     BS         .               .             NONE             .           .
      74  EQ2DJ     BS         .               .             NONE             .           .
      75  EQ2DL     BS         .               .             NONE             .           .
      76  EQ2DM     UL         .               .             NONE             .      2384.72727
      77  EQ2DP     BS         .               .             NONE             .           .
      78  EQ2DQ     UL         .               .             NONE             .      2384.72727
A     79  EQ3DF     UL         .               .             NONE             .           .
      80  EQ3DG     BS         .               .             NONE             .           .
      81  EQ3DI     BS         .               .             NONE             .           .
      82  EQ3DJ     UL         .               .             NONE             .      5581.00000
      83  EQ3DL     UL         .               .             NONE             .      3030.00000
      84  EQ3DM     BS         .               .             NONE             .           .
      85  EQ3DP     UL         .               .             NONE             .      2186.00000
      86  EQ3DQ     UL         .               .             NONE             .      4222.36364
      87  EQ5DF     BS         .            1.00000          NONE          1.00000        .
      88  EQ5DG     BS         .            1.00000          NONE          1.00000        .
      89  EQ5DI     BS         .            1.00000          NONE          1.00000        .
      90  EQ5DJ     BS         .            1.00000          NONE          1.00000        .
      91  EQ5DL     BS         .            1.00000          NONE          1.00000        .
      92  EQ5DM     BS         .            1.00000          NONE          1.00000        .
      93  EQ5DP     BS         .            1.00000          NONE          1.00000        .
      94  EQ5DQ     BS         .            1.00000          NONE          1.00000        .
A     95  EQ6DF     EQ         .               .              .               .           .
A     96  EQ6DG     EQ         .               .              .               .           .
A     97  EQ6DI     EQ         .               .              .               .           .
      98  EQ6DJ     EQ         .               .              .               .      5581.00000-
      99  EQ6DL     EQ         .               .              .               .      3030.00000-
     100  EQ6DM     EQ         .               .              .               .      2384.72727-
```

298

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 NUMBER  ...ROW.. AT   ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

     101  EQ6DP    EQ        .               .               .               .           2186.00000-
     102  EQ6DQ    EQ        .               .               .               .           6607.09091-
     103  HDF      EQ        .               .               .               .               .25720
     104  HDG      EQ        .               .               .               .               .25720
     105  HDI      EQ        .               .               .               .               .25720
 A   106  HDJ      EQ        .               .               .               .               .
     107  HDL      EQ        .               .               .               .               .25720
     108  HDM      EQ        .               .               .               .               .24214
     109  HDP      EQ        .               .               .               .               .00061
     110  HDQ      EQ        .               .               .               .               .24214
     111  JDE      EQ        .               .               .               .               .04384-
     112  JDG      EQ        .               .               .               .               .03900-
     113  JDI      EQ        .               .               .               .               .03727-
 A   114  JDJ      EQ        .               .               .               .               .
 A   115  JDL      EQ        .               .               .               .               .
     116  JDM      EQ        .               .               .               .               .03509-
     117  JDP      EQ        .               .               .               .               .00068-
     118  JDQ      EQ        .               .               .               .               .04104-
     119  SIZYDN   EQ        .               .               .               .               .78682-
     120  SIZYDP   EQ        .               .               .               .               .78682-
     121  SIZYMA   EQ        .               .               .               .               .78682-
     122  SIZYMB   EQ        .               .               .               .               .78682-
     123  SIZYMC   EQ        .               .               .               .               .78682-
     124  SIZYMD   EQ        .               .               .               .               .78682-
     125  SIZYPA   EQ        .               .               .               .               .78682-
     126  SIZYPB   EQ        .               .               .               .               .78682-
 A   127  EQ03DN   EQ        .               .               .               .               .
 A   128  EQ03DP   EQ        .               .               .               .               .
 A   129  EQ03MA   EQ        .               .               .               .               .
 A   130  EQ03MB   EQ        .               .               .               .               .
 A   131  EQ03MC   EQ        .               .               .               .               .
 A   132  EQ03MD   EQ        .               .               .               .               .
 A   133  EQ03PA   EQ        .               .               .               .               .
 A   134  EQ03PB   EQ        .               .               .               .               .
     135  EDN      EQ        .               .               .               .               .78682-
     136  EDP      EQ        .               .               .               .               .78682-
     137  EMA      EQ        .               .               .               .               .78682-
     138  EMB      EQ        .               .               .               .               .78682-
     139  EMC      EQ        .               .               .               .               .78682-
     140  EMD      EQ        .               .               .               .               .78682-
     141  EPA      EQ        .               .               .               .               .78682-
     142  EPB      EQ        .               .               .               .              2.68849-
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299

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SECTION 2 - COLUMNS

 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

    145  WMCDA     BS      917.32129          .               .              NONE            .
    153  WMCDB     BS      637.96151          .               .              NONE            .
    159  WMADC     BS      882.94529          .               .              NONE            .
    191  WMADG     BS     3230.82464          .               .              NONE            .
    199  WMADH     BS     3234.56045          .               .              NONE            .
    209  WMCDI     BS     2121.90691          .               .              NONE            .
    225  WMCDK     BS     1642.82207          .               .              NONE            .
    233  WMCDL     BS     4272.24077          .               .              NONE            .
    241  WMCDM     BS     1549.98036          .               .              NONE            .
    252  WMFDN     BS     5505.52249          .               .              NONE            .
    255  WMADO     BS     1275.55360          .               .              NONE            .
    268  WMFDP     BS     2441.79598          .               .              NONE            .
    271  WMADQ     BS     1568.44079          .               .              NONE            .
    279  WMADR     BS      909.49442          .               .              NONE            .
    297  WSMCDG    BS          .              .               .              NONE            .
    305  WSMCDI    BS          .              .               .              NONE            .
    329  WSMCDM    BS          .              .               .              NONE            .
    335  WSMADP    BS          .              .               .              NONE            .
    340  WSMFDP    BS          .              .               .              NONE            .
    343  WSMADQ    BS          .              .               .              NONE            .
   1146  XMDDPDD   BS      837.71257          .               .              NONE            .
   1354  XMDDPDE   BS     1025.18648          .               .              NONE            .
   1562  XMDDPDF   BS     2490.37810          .               .              NONE            .
   2394  XMDDPDJ   BS     2646.72285          .               .              NONE            .
   2395  XMFDPDJ   BS          .              .               .              NONE            .
   2396  XMFDPDJ   BS       52.68153          .               .              NONE            .
   2399  XMADQDJ   BS      156.56041          .               .              NONE            .
   4271  XSMADQDF  BS          .              .               .              NONE            .
   4892  XSMFDPDJ  BS          .              .               .              NONE            .
   4895  XSMADQDJ  BS          .              .               .              NONE            .
   5917  YMDPBDD   BS          .              .               .              NONE            .
   6181  YMCMCDK   BS          .              .               .              NONE            .
   6799  SS1DF     BS          .              .               .              NONE            .
   6800  SS1DG     BS          .              .               .              NONE            .
   6801  SS1DI     BS          .              .               .              NONE            .
   6802  SS1DJ     BS          .              .               .              NONE            .
   6803  SS1DL     BS          .              .               .              NONE            .
   6804  SS1DM     BS          .              .               .              NONE            .
   6806  SS1DQ     BS          .              .               .              NONE            .
   6810  SS2DJ     BS          .              .               .              NONE            .
   6811  SS2DL     BS          .              .               .              NONE            .
   6817  S3DF      BS          .              .               .              NONE            .
   6820  S3DG      BS          .              .               .              NONE            .
   6823  S3DI      BS          .              .               .              NONE            .
   6824  S1DJ      BS          .              .               .              NONE            .
   6828  S2DL      BS          .              .               .              NONE            .
   6829  S3DL      BS          .              .               .              NONE            .
   6830  S1DM      BS          .              .               .              NONE            .
   6832  S3DM      BS          .              .               .              NONE            .
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300

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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                              PAGE    22  -  74/183
   NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

     6833  S1DP      BS        .                .               .              NONE            .
     6835  S3DP      BS        .                .               .              NONE            .
     6836  S1DQ      BS        .                .               .              NONE            .
     6837  S2DQ      BS        .                .               .              NONE            .
     6838  S3DQ      BS        .                .               .              NONE            .
     6839  CC1DN     BS        .                .               .              NONE            .
     6840  CC1DP     BS        .                .               .              NONE            .
     6841  CC1MA     BS        .                .               .              NONE            .
     6842  CC1MB     BS        .                .               .              NONE            .
     6843  CC1MC     BS        .                .               .              NONE            .
     6844  CC1MD     BS        .                .               .              NONE            .
     6845  CC1PA     BS        .                .               .              NONE            .
     6847  C1DN      BS        .                .               .              NONE            .
     6849  C1DP      BS        .                .               .              NONE            .
     6851  C1MA      BS        .                .               .              NONE            .
     6852  C2MA      BS        .                .               .              NONE            .
     6853  C1MB      BS        .                .               .              NONE            .
     6856  C2MC      BS        .                .               .              NONE            .
     6857  C1MD      BS        .                .               .              NONE            .
     6859  C1PA      BS        .                .               .              NONE            .
     6861  C1PB      BS        .                .               .              NONE            .
     6881  TPIT      BS  220503.82821        1.00000            .              NONE            .
     6882  TERT      BS   99144.19782        1.00000            .              NONE            .
     6883  TASH      BS    4784.46465        1.00000            .              NONE            .
     6884  TSC1      BS        .             1.00000            .              NONE            .
     6887  TREE      BS        .             1.00000            .              NONE            .
     6888  TSTO      BS    2162.77258        1.00000            .              NONE            .
     6889  TBRN      BS        .             1.00000            .              NONE            .
     6890  IN12DF    IV        .                .               .           1.00000            .
     6891  IN12DG    IV        .                .               .           1.00000            .
     6892  IN12DI    IV        .                .               .           1.00000            .
     6894  IN12DL    IV        .                .               .           1.00000            .
     6897  IN12DQ    IV        .                .               .           1.00000            .
     6898  IN23DF    IV        .                .               .           1.00000            .
     6899  IN23DG    IV        .                .               .           1.00000            .
     6900  IN23DI    IV        .                .               .           1.00000            .
     6901  IN23DJ    IV        .                .               .           1.00000            .
     6902  IN23DL    IV        .                .               .           1.00000            .
     6903  IN23DM    IV        .                .               .           1.00000            .
     6904  IN23DP    IV        .                .               .           1.00000            .
     6905  IN23DQ    IV        .                .               .           1.00000            .
     6906  IM12DN    IV        .                .               .           1.00000            .
     6907  IM12DP    IV        .                .               .           1.00000            .
     6909  IM12MB    IV        .                .               .           1.00000            .
     6910  IM12MC    IV        .                .               .           1.00000            .
     6911  IM12MD    IV        .                .               .           1.00000            .
     6912  IM12PA    IV        .                .               .           1.00000            .
     6913  IM12PB    IV        .                .               .           1.00000            .
```

Case 3: Spec. = 5 lb SO_2/MMBtu

C.

```
MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                          PAGE    19  -  74/179
SECTION 1 - ROWS

 NUMBER  ...ROW..  AT  ...ACTIVITY...   SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

      1  COSTTOTL  BS   381681.55020    381681.55020-          NONE            NONE           1.00000
      2  COSTPIT   EQ         .                .                 .               .            1.00000
      3  COSTFRT   EQ         .                .                 .               .            1.00000
      4  COSTASH   EQ         .                .                 .               .            1.00000
      5  COSTSC1   EQ         .                .                 .               .            1.00000
      6  COSTSC2   EQ         .                .                 .               .            1.00000
      7  COSTWSH   EQ         .                .                 .               .             .09273
      8  COSTREF   EQ         .                .                 .               .            1.00000
      9  COSTSTO   EQ         .                .                 .               .            1.00000
     10  COSTBRN   EQ         .                .                 .               .            1.00000
     11  AMA       BS     5404.12479     44595.87521           NONE       50000.00000             .
     12  AMB       BS     7200.00000     42800.00000           NONE       50000.00000             .
     13  AMC       BS     1886.64147     48113.35853           NONE       50000.00000             .
     14  AMD       UL     7000.00000           .               NONE        7000.00000          2.31280
     15  AME       UL           .              .               NONE             .              1.68732
     16  AMF       UL     8000.00000           .               NONE        8000.00000           .61434
     17  AMG       UL     8000.00000           .               NONE        8000.00000           .01962
     18  AMH       BS           .              .               NONE             .                 .
     19  DDA       EQ    18684.00000           .        18684.00000       18684.00000           .64516-
     20  DDB       EQ    12994.00000           .        12994.00000       12994.00000           .64516-
     21  DDC       EQ    17726.00000           .        17726.00000       17726.00000           .48481-
     22  DDD       EQ    20023.00000           .        20023.00000       20023.00000           .53426-
     23  DDE       EQ    24504.00000           .        24504.00000       24504.00000           .51322-
     24  DDF       EQ    59525.00000           .        59525.00000       59525.00000           .49744-
     25  DDG       EQ    64862.00000           .        64862.00000       64862.00000           .59202-
     26  DDH       EQ    64937.00000           .        64937.00000       64937.00000           .59202-
     27  DDI       EQ    43219.00000           .        43219.00000       43219.00000           .67006-
     28  DDJ       EQ    67512.00000           .        67512.00000       67512.00000           .48955-
     29  DDK       EQ    33461.00000           .        33461.00000       33461.00000           .52376-
     30  DDL       EQ    87017.00000           .        87017.00000       87017.00000           .56323-
     31  DDM       EQ    31570.00000           .        31570.00000       31570.00000           .65801-
     32  DDN       EQ   115682.00000           .       115682.00000      115682.00000           .39541-
     33  DDO       EQ    25608.00000           .        25608.00000       25608.00000           .58875-
     34  DDP       EQ    51307.00000           .        51307.00000       51307.00000           .45228-
     35  DDQ       EQ    31488.00000           .        31488.00000       31488.00000           .46107-
     36  DDR       EQ    18259.00000           .        18259.00000       18259.00000           .62273-
     37  EDA       UL    93420.00000           .               NONE       93420.00000           .02226
     38  EDB       UL    64970.00000           .               NONE       64970.00000           .02226
     39  EDC       UL    88630.00000           .               NONE       88630.00000           .00028
     40  EDD       UL   100115.00000           .               NONE      100115.00000           .00071
     41  EDE       UL   122520.00000           .               NONE      122520.00000           .00052
     42  EDF       UL   297625.00000           .               NONE      297625.00000           .00039
     43  EDG       UL   324310.00000           .               NONE      324310.00000           .00987
     44  EDH       UL   324685.00000           .               NONE      324685.00000           .00987
     45  EDI       UL   216095.00000           .               NONE      216095.00000           .02125
     46  EDJ       UL   337560.00000           .               NONE      337560.00000           .00032
     47  EDK       UL   167305.00000           .               NONE      167305.00000        [illegible]
     48  EDL       UL   435085.00000           .               NONE      435085.00000           .01256
     49  EDM       UL   157850.00000           .               NONE      157850.00000           .01464
```

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NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

    50  EDN       BS   198198.80960    380211.19039        NONE       578410.00000           .
    51  EDO       UL   128040.00000          .             NONE       128040.00000        .02229
    52  EDP       BS   180701.91795     75833.08205        NONE       256535.00000           .
    53  EDQ       UL   157440.00000          .             NONE       157440.00000        .00162
    54  EDR       UL    91295.00000          .             NONE        91295.00000        .02186
    55  SIZXDF    EQ         .               .               .               .            .25720
    56  SIZXDG    EQ         .               .               .               .            .25720
    57  SIZXDI    EQ         .               .               .               .            .25720
    58  SIZXDJ    EQ         .               .               .               .            .24214
    59  SIZXDL    EQ         .               .               .               .            .24214
    60  SIZXDM    EQ         .               .               .               .            .25720
    61  SIZXDP    EQ         .               .               .               .            .17817
    62  SIZXDQ    EQ         .               .               .               .            .25720
    63  EQ1CF     BS         .               .             NONE              .               .
    64  EQ1CG     BS         .               .             NONE              .               .
    65  EQ1DI     BS         .               .             NONE              .               .
    66  EQ1DJ     UL         .               .             NONE              .               .
    67  EQ1DL     BS         .               .             NONE              .               .
    68  EQ1DM     UL         .               .             NONE              .         844.00000
    69  EQ1DP     UL         .               .             NONE              .        9289.20000
    70  EQ1DQ     BS         .               .             NONE              .               .
    71  EQ2CF     BS         .               .             NONE              .               .
    72  EQ2CG     BS         .               .             NONE              .               .
    73  EQ2DI     BS         .               .             NONE              .               .
    74  EQ2DJ     UL         .               .             NONE              .        2384.72727
    75  EQ2CL     BS         .               .             NONE              .               .
    76  EQ2CM     BS         .               .             NONE              .               .
    77  EQ2DP     UL         .               .             NONE              .        3229.20000
    78  EQ2CQ     BS         .               .             NONE              .               .
    79  EQ3DF     UL         .               .             NONE              .        2186.00000
    80  EQ3DG     UL         .               .             NONE              .        2186.00000
    81  EQ3DI     UL         .               .             NONE              .        2186.00000
    82  EQ3DJ     BS         .               .             NONE              .               .
    83  EQ3CL     BS         .               .             NONE              .               .
    84  EQ3DM     UL         .               .             NONE              .        3030.00000
    85  EQ3DP     BS         .               .             NONE              .               .
    86  EQ3DQ     UL         .               .             NONE              .        2186.00000
    87  EQ5CF     BS         .            1.00000          NONE           1.00000            .
    88  EQ5DG     BS         .            1.00000          NONE           1.00000            .
    89  EQ5DI     BS         .            1.00000          NONE           1.00000            .
    90  EQ5CJ     BS         .            1.00000          NONE           1.00000            .
    91  EQ5DL     BS         .            1.00000          NONE           1.00000            .
    92  EQ5DM     BS         .            1.00000          NONE           1.00000            .
    93  EQ5DP     BS         .            1.00000          NONE           1.00000            .
    94  EQ5CQ     BS         .            1.00000          NONE           1.00000            .
    95  EQ6CF     EQ         .               .               .               .        2186.00000-
    96  EQ6DG     EQ         .               .               .               .        2186.00000-
    97  EQ6DI     EQ         .               .               .               .        2186.00000-
    98  EQ6DJ     EQ         .               .               .               .        2384.72727-
    99  EQ6CL     EQ         .               .               .               .        2384.72727-
   100  EQ6DM     EQ         .               .               .               .        3030.00000-
```

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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                   PAGE    21  -  74/179

  NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

     101  EQ6DP     EQ        .               .               .               .         12518.40000-
     102  EQ6DQ     EQ        .               .               .               .          2186.00000-
     103  HDF       EQ        .               .               .               .              .00001
     104  HDG       EQ        .               .               .               .              .25720
     105  HDI       EQ        .               .               .               .              .25720
     106  HDJ       EQ        .               .               .               .              .00001
     107  HDL       EQ        .               .               .               .              .24214
     108  HDM       EQ        .               .               .               .              .25720
     109  HDP       EQ        .               .               .               .              .17817
     110  HDQ       EQ        .               .               .               .              .00011-
     111  JDF       EQ        .               .               .               .              .00058
     112  JDG       EQ        .               .               .               .              .02413-
     113  JDI       EQ        .               .               .               .              .00292
     114  JDJ       EQ        .               .               .               .              .00048
     115  JDL       EQ        .               .               .               .              .01290-
     116  JDM       EQ        .               .               .               .              .01150-
     117  JDP       EQ        .               .               .               .              .03020-
     118  JDQ       EQ        .               .               .               .              .00292
     119  SIZYDN    EQ        .               .               .               .             4.05059-
     120  SIZYDP    EQ        .               .               .               .             1.15739-
     121  SIZYMA    EQ        .               .               .               .             1.90000
     122  SIZYMB    EQ        .               .               .               .              .17239
     123  SIZYMC    EQ        .               .               .               .             1.90000
     124  SIZYMD    EQ        .               .               .               .             1.90000
     125  SIZYPA    EQ        .               .               .               .             1.90000
     126  SIZYPB    EQ        .               .               .               .             1.90000
A    127  EQ03DN    EQ        .               .               .               .                  .
A    128  EQ03DP    EQ        .               .               .               .                  .
A    129  EQ03MA    EQ        .               .               .               .                  .
     130  EQ03MB    EQ        .               .               .               .         12438.79534-
A    131  EQ03MC    EQ        .               .               .               .                  .
A    132  EQ03MD    EQ        .               .               .               .                  .
A    133  EQ03PA    EQ        .               .               .               .                  .
A    134  EQ03PB    EQ        .               .               .               .                  .
     135  FDN       EQ        .               .               .               .             4.05059-
     136  FDP       EQ        .               .               .               .             1.15739-
     137  FMA       EQ        .               .               .               .             1.90000
     138  FMB       EQ        .               .               .               .              .17239
     139  FMC       EQ        .               .               .               .             1.90000
     140  FMD       EQ        .               .               .               .             1.90000
     141  FPA       EQ        .               .               .               .             1.90000
     142  FPB       EQ        .               .               .               .             1.90000
```

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MPSX-PTB13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                                PAGE    22  -  74/179
SECTION 2 - COLUMNS

NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

   145  WMCDA     BS      131.58256         .               .            NONE             .
   153  WMCCB     BS       91.51059         .               .            NONE             .
   159  WMADC     BS      296.88460         .               .            NONE             .
   191  WMADG     BS     1287.64961         .               .            NONE             .
   195  WMADH     BS     1289.13852         .               .            NONE             .
   207  WMADI     BS      657.98971         .               .            NONE             .
   225  WMCDK     BS      518.11632         .               .            NONE             .
   233  WMCDL     BS      612.81952         .               .            NONE             .
   241  WMCDM     BS      532.61249         .               .            NONE             .
   252  WMFDN     BS     5505.52249         .               .            NONE             .
   255  WMADO     BS      224.58233         .               .            NONE             .
   263  WMADP     BS      460.29552         .               .            NONE             .
   266  WMFDP     BS     2002.00486         .               .            NONE             .
   271  WMADO     BS      625.10424         .               .            NONE             .
   279  WMADR     BS      362.48025         .               .            NONE             .
   297  WSMCDG    BS          .             .               .            NONE             .
   321  WSMCDL    BS          .             .               .            NONE             .
   329  WSMCDH    BS          .             .               .            NONE             .
   335  WSMADP    BS          .             .               .            NONE             .
   343  WSMADQ    BS          .             .               .            NONE             .
   938  XMDDPDC   BS      111.27111         .               .            NONE             .
   939  XMEDPDC   BS          .             .               .            NONE             .
   941  XMGDPDC   BS      397.30134         .               .            NONE             .
  1146  XMDDPDD   BS      803.97414         .               .            NONE             .
  1149  XMGDPDD   BS       35.18394         .               .            NONE             .
  1354  XMDDPDE   BS      983.89763         .               .            NONE             .
  1357  XMGDPDE   BS       43.05784         .               .            NONE             .
  1562  XMDDPDF   BS     2390.07943         .               .            NONE             .
  1565  XMGDPDF   BS      104.59591         .               .            NONE             .
  1773  XMDDPDG   BS     1702.05762         .               .            NONE             .
  1991  XMGDPDH   BS     1704.02571         .               .            NONE             .
  2139  XMDDPDI   BS     1134.11902         .               .            NONE             .
  2394  XMDDPDJ   BS     2710.77770         .               .            NONE             .
  2397  XMGDPDJ   BS      118.63047         .               .            NONE             .
  2588  XMFDNDK   BS      492.47265         .               .            NONE             .
  2589  XMGDNDK   BS      548.00066         .               .            NONE             .
  3021  XMGDPDM   BS      904.09026         .               .            NONE             .
  3437  XMGDPDO   BS        3.51556         .               .            NONE             .
  3851  XMGDPDQ   BS   [illegible].28334    .               .            NONE             .
  4069  XMGDPDR   BS   [illegible].13832    .               .            NONE             .
  4266  XSMDDPDF  BS          .             .               .            NONE             .
  4269  XSMGDPDF  BS          .             .               .            NONE             .
  4890  XSMDDPDJ  BS          .             .               .            NONE             .
  4893  XSMGDPDJ  BS          .             .               .            NONE             .
  5733  XSMGDPDC  BS          .             .               .            NONE             .
  5775  YMBMHDA   BS      539.19877         .               .            NONE             .
  5815  YMBMHDB   BS      653.17645         .               .            NONE             .
  5844  YMADPDC   BS          .             .               .            NONE             .
  6162  YMDDNDK   BS          .             .               .            NONE             .
```

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MPSX-PTF13      EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                              PAGE    23  -  74/179
 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

   6715  YMBMBCL   BS     4374.13077          .               .              NONE             .
   6335  YMBMPDO   BS     1233.49401          .               .              NONE             .
   6800  SS1DG     BS          .              .               .              NONE             .
   6801  SS1DI     BS          .              .               .              NONE             .
   6803  SS1DL     BS          .              .               .              NONE             .
   6804  SS1DM     BS          .              .               .              NONE             .
   6805  SS1DP     BS          .              .               .              NONE             .
   6809  SS2DI     BS          .              .               .              NONE             .
   6814  SS2DO     BS          .              .               .              NONE             .
   6815  S1DF      BS          .              .               .              NONE             .
   6817  S3DF      BS          .              .               .              NONE             .
   6818  S1DG      BS          .              .               .              NONE             .
   6820  S3DG      BS          .              .               .              NONE             .
   6821  S1DI      BS          .              .               .              NONE             .
   6823  S3DI      BS          .              .               .              NONE             .
   6824  S1DJ      BS          .              .               .              NONE             .
   6826  S3DJ      BS          .              .               .              NONE             .
   6827  S1DL      BS          .              .               .              NONE             .
   6829  S3DL      BS          .              .               .              NONE             .
   6830  S1DM      BS          .              .               .              NONE             .
   6831  S2DM      BS          .              .               .              NONE             .
   6832  S3DM      BS          .              .               .              NONE             .
   6833  S1DP      BS          .              .               .              NONE             .
   6834  S2DP      BS          .              .               .              NONE             .
   6835  S3DP      BS          .              .               .              NONE             .
   6836  S1DQ      BS          .              .               .              NONE             .
   6838  S3DQ      BS          .              .               .              NONE             .
   6839  CC1DN     BS          .              .               .              NONE             .
   6840  CC1DP     BS          .              .               .              NONE             .
   6841  CC1MA     BS          .              .               .              NONE             .
   6842  CC1MB     BS     7200.00000          .               .              NONE             .
   6843  CC1MC     BS          .              .               .              NONE             .
   6844  CC1MD     BS          .              .               .              NONE             .
   6845  CC1PA     BS          .              .               .              NONE             .
   6846  CC1PB     BS          .              .               .              NONE             .
   6851  C1MA      BS          .              .               .              NONE             .
   6852  C2MA      BS          .              .               .              NONE             .
   6853  C1MB      BS        1.00000          .               .              NONE             .
   6855  C1MC      BS          .              .               .              NONE             .
   6857  C1MD      BS          .              .               .              NONE             .
   6859  C1PA      BS          .              .               .              NONE             .
   6861  C1PB      BS          .              .               .              NONE             .
   6881  TPIT      BS   211067.28916       1.00000            .              NONE             .
   6882  TERT      BS   146209.49686       1.00000            .              NONE             .
   6883  TASH      BS     3470.62239       1.00000            .              NONE             .
   6884  TSC1      BS          .           1.00000            .              NONE             .
   6886  TWSH      BS    13680.00000       1.00000            .              NONE             .
   6887  TPEF      BS      446.40000       1.00000            .              NONE             .
   6888  TSTC      BS     6607.74179       1.00000            .              NONE             .
   6889  TBRN      BS          .           1.00000            .              NONE             .
   6893  IN12DJ    IV          .              .               .            1.00000            .
```

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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                          PAGE    24  -  74/179

 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

   6896  IN12DP    IV        .               .               .            1.00000          .
   6898  IN23DF    IV        .               .               .            1.00000          .
   6899  IN23DG    IV        .               .               .            1.00000          .
   6900  IN23DI    IV        .               .               .            1.00000          .
   6901  IN23DJ    IV        .               .               .            1.00000          .
   6903  IN23DM    IV        .               .               .            1.00000          .
   6905  IN23DO    IV        .               .               .            1.00000          .
   6906  IM12DN    IV        .               .               .            1.00000          .
   6907  IM12DP    IV        .               .               .            1.00000          .
   6909  IM124B    IV     1.00000            .               .            1.00000     12438.79534
   6910  IM12MC    IV        .               .               .            1.00000          .
   6911  IM124D    IV        .               .               .            1.00000          .
   6912  IM12P4    IV        .               .               .            1.00000          .
   6913  IM12PB    IV        .               .               .            1.00000          .
```

Case 3: Spec. = 3.1 lb SO_2/MMBtu

```
SECTION 1 - ROWS

NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

     1  COSTTOTL  BS  414977.07576    414977.07576-           NONE            NONE          1.00000
     2  COSTPIT   EQ        .               .                .               .              1.00000
     3  COSTFRT   EQ        .               .                .               .              1.00000
     4  COSTASH   EQ        .               .                .               .              1.00000
     5  COSTSC1   EQ        .               .                .               .              1.00000
     6  COSTSC2   EQ        .               .                .               .              1.00000
     7  COSTWSH   EQ        .               .                .               .              1.00000
     8  COSTREF   EQ        .               .                .               .              1.00000
     9  COSTSTO   EQ        .               .                .               .              1.00000
    10  COSTBRN   EQ        .               .                .               .              1.00000
    11  AMA       BS     338.13609     49661.86391            NONE      50000.00000             .
    12  AMB       BS   14398.39058     35601.60942            NONE      50000.00000             .
    13  AMC       BS     857.78819     49142.21181            NONE      50000.00000             .
    14  AMD       UL    7000.00000          .                 NONE       7000.00000         4.92086
    15  AME       UL        .               .                 NONE            .             3.35164
    16  AMF       UL    8000.00000          .                 NONE       8000.00000         5.18666
    17  AMG       UL    8000.00000          .                 NONE       8000.00000         5.88627
    18  AMH       UL        .               .                 NONE            .             3.13131
    19  DDA       EQ   18684.00000          .          18684.00000      18684.00000          .95392-
    20  DDB       EQ   12994.00000          .          12994.00000      12994.00000          .95392-
    21  DDC       EQ   17726.00000          .          17726.00000      17726.00000          .75726-
    22  DDD       EQ   20023.00000          .          20023.00000      20023.00000          .80670-
    23  DDE       EQ   24504.00000          .          24504.00000      24504.00000          .78566-
    24  DDF       EQ   59525.00000          .          59525.00000      59525.00000          .76988-
    25  DDG       EQ   64862.00000          .          64862.00000      64862.00000          .85991-
    26  DDH       EQ   64937.00000          .          64937.00000      64937.00000          .85991-
    27  DDI       EQ   43219.00000          .          43219.00000      43219.00000          .95230-
    28  DDJ       EQ   67512.00000          .          67512.00000      67512.00000          .76199-
    29  DDK       EQ   33461.00000          .          33461.00000      33461.00000          .77288-
    30  DDL       EQ   87017.00000          .          87017.00000      87017.00000          .97709-
    31  DDM       EQ   31570.00000          .          31570.00000      31570.00000          .93142-
    32  DDN       EQ  115682.00000          .         115682.00000     115682.00000          .62256-
    33  DDO       EQ   25608.00000          .          25608.00000      25608.00000          .87129-
    34  DDP       EQ   51307.00000          .          51307.00000      51307.00000          .72253-
    35  DDQ       EQ   31488.00000          .          31488.00000      31488.00000          .75279-
    36  DDR       EQ   18259.00000          .          18259.00000      18259.00000          .90505-
    37  EDA       UL   57920.38672          .                 NONE      57920.38672          .08037
    38  EDB       UL   40281.39063          .                 NONE      40281.39063          .08037
    39  EDC       UL   54950.58984          .                 NONE      54950.58984          .03176
    40  EDD       UL   62071.28516          .                 NONE      62071.28516          .03219
    41  EDE       UL   75962.37500          .                 NONE      75962.37500          .03201
    42  EDF       UL  184527.43750          .                 NONE     184527.43750          .03187
    43  EDG       UL  201072.12500          .                 NONE     201072.12500          .03266
    44  EDH       UL  201304.62500          .                 NONE     201304.62500          .03266
    45  EDI       UL  133978.87500          .                 NONE     133978.87500          .07145
    46  EDJ       UL  209287.12500          .                 NONE     209287.12500          .03180
    47  EDK       UL  103729.06250          .                 NONE     103729.06250          .02042
    48  EDL       UL  269752.62500          .                 NONE     269752.62500          .10013
    49  EDM       UL   97866.93750          .                 NONE      97866.93750          .04791
```

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 NUMBER  ...ROW..  AT  ...ACTIVITY...   SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

     50  EDN       UL   358614.12500          .              NONE      358614.12500         .00557
     51  EDO       UL    79384.75000          .              NONE       79384.75000         .07306
     52  EDP       UL   159051.62500          .              NONE      159051.62500         .03073
     53  EDQ       UL    97612.75000          .              NONE       97612.75000         .03172
     54  EDR       UL    56602.88672          .              NONE       56602.88672         .07220
     55  SIZXDF    EQ         .               .               .               .             .25720
     56  SIZXDG    EQ         .               .               .               .             .24214
     57  SIZXDI    EQ         .               .               .               .             .26226
     58  SIZXDJ    EQ         .               .               .               .             .25720
     59  SIZXDL    EQ         .               .               .               .             .29429
     60  SIZXDM    EQ         .               .               .               .             .25720
     61  SIZXDP    EQ         .               .               .               .             .24214
     62  SIZXDQ    EQ         .               .               .               .             .24214
     63  EQ1DF     BS         .               .              NONE             .               .
     64  EQ1DG     BS         .               .              NONE             .               .
     65  EQ1DI     BS         .               .              NONE             .               .
     66  EQ1DJ     UL         .               .              NONE             .          844.00000
     67  EQ1DL     BS         .               .              NONE             .               .
     68  EQ1DM     UL         .               .              NONE             .          844.00000
     69  EQ1DP     UL         .               .              NONE             .         4222.36364
     70  EQ1DQ     UL         .               .              NONE             .         4222.36364
     71  EQ2DF     BS         .               .              NONE             .               .
     72  EQ2DG     UL         .               .              NONE             .         2384.72727
     73  EQ2DI     BS         .               .              NONE             .               .
     74  EQ2DJ     BS         .               .              NONE             .               .
     75  EQ2DL     BS         .               .              NONE             .               .
     76  EQ2DM     BS         .               .              NONE             .               .
     77  EQ2DP     UL         .               .              NONE             .         2384.72727
     78  EQ2DQ     UL         .               .              NONE             .         2384.72727
     79  EQ3DF     UL         .               .              NONE             .         2186.00000
     80  EQ3DG     BS         .               .              NONE             .               .
     81  EQ3DI     UL         .               .              NONE             .         2920.50064
     82  EQ3DJ     UL         .               .              NONE             .         3030.00000
     83  EQ3DL     UL         .               .              NONE             .         5875.62004
     84  EQ3DM     UL         .               .              NONE             .         3030.00000
     85  EQ3DP     UL         .               .              NONE             .         4222.36364
     86  EQ3DQ     UL         .               .              NONE             .         4222.36364
     87  EQ5DF     BS         .            1.00000           NONE          1.00000            .
     88  EQ5DG     BS         .            1.00000           NONE          1.00000            .
     89  EQ5DI     BS         .            1.00000           NONE          1.00000            .
     90  EQ5DJ     BS         .            1.00000           NONE          1.00000            .
     91  EQ5DL     BS         .            1.00000           NONE          1.00000            .
     92  EQ5DM     BS         .            1.00000           NONE          1.00000            .
     93  EQ5DP     BS         .            1.00000           NONE          1.00000            .
     94  EQ5DQ     BS         .            1.00000           NONE          1.00000            .
     95  EQ6DF     EQ         .               .               .               .         2186.00000-
     96  EQ6DG     EQ         .               .               .               .         2384.72727-
     97  EQ6DI     EQ         .               .               .               .         2119.22721-
     98  EQ6DJ     EQ         .               .               .               .         3030.00000-
A    99  EQ6DL     EQ         .               .               .               .               .
    100  EQ6DM     EQ         .               .               .               .         3030.00000-
```

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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                   PAGE    20  -  74/179

NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

    101  EQ6DP     EQ        .               .               .               .          6607.09091-
    102  EQ6DQ     EQ        .               .               .               .          6607.09091-
    103  HDF       EQ        .               .               .               .              .05297
    104  HDG       EQ        .               .               .               .              .24214
    105  HDI       EQ        .               .               .               .              .26226
    106  HDJ       EQ        .               .               .               .              .25720
    107  HDL       EQ        .               .               .               .              .29429
    108  HDM       EQ        .               .               .               .              .25720
    109  HDP       EQ        .               .               .               .              .24214
    110  HDQ       EQ        .               .               .               .              .24214
    111  JDF       EQ        .               .               .               .              .03150
    112  JDG       EQ        .               .               .               .              .01752
    113  JDI       EQ        .               .               .               .              .03150
    114  JDJ       EQ        .               .               .               .              .00340-
    115  JDL       EQ        .               .               .               .              .03150
    116  JDM       EQ        .               .               .               .              .03150
    117  JDP       EQ        .               .               .               .              .00136-
    118  JDQ       EQ        .               .               .               .              .00192
    119  SI7YDN    EQ        .               .               .               .             1.90000
    120  SI7YDP    EQ        .               .               .               .             1.90000
    121  SI7YMA    EQ        .               .               .               .             2.31561
    122  SI7YMB    EQ        .               .               .               .             1.90000
    123  SI7YMC    EQ        .               .               .               .             1.21624
    124  SI7YMD    EQ        .               .               .               .             1.90000
    125  SI7YPA    EQ        .               .               .               .             1.90000
    126  SI7YPB    EQ        .               .               .               .             1.90000
A   127  EQC3DN    EQ        .               .               .               .                .
A   128  EQC3DP    EQ        .               .               .               .                .
    129  EQC3MA    EQ        .               .               .               .         99745.32085
A   130  EQC3MB    EQ        .               .               .               .                .
A   131  EQC3MC    EQ        .               .               .               .                .
A   132  EQC3MD    EQ        .               .               .               .                .
A   133  EQC3PA    EQ        .               .               .               .                .
A   134  EQC3PB    EQ        .               .               .               .                .
    135  FDN       EQ        .               .               .               .             1.90000
    136  FDP       EQ        .               .               .               .             1.90000
    137  FMA       EQ        .               .               .               .             2.31561
    138  FMB       EQ        .               .               .               .             1.90000
    139  FMC       EQ        .               .               .               .             1.21624
    140  FMD       EQ        .               .               .               .             1.90000
    141  FPA       EQ        .               .               .               .             1.90000
    142  FPB       EQ        .               .               .               .             1.90000
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MPSX-PTF13    EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                    PAGE   21  -  74/179
SECTION 2 - COLUMNS

 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

    199  WMADH     BS       338.13609          .               .             NONE            .
    225  WMCDK     BS       192.44515          .               .             NONE            .
    249  WMCDN     BS       665.33904          .               .             NONE            .
    251  WMEDN     BS            .             .               .             NONE            .
    252  WMFDN     BS      4860.57531          .               .             NONE            .
    254  WMHDN     BS            .             .               .             NONE            .
    266  WMDDP     BS       856.69138          .               .             NONE            .
    268  WMFDP     BS      1467.27484          .               .             NONE            .
    295  WSMACG    BS            .             .               .             NONE            .
    303  WSMADI    BS            .             .               .             NONE            .
    320  WSMPCL    BS            .             .               .             NONE            .
    335  WSMACP    BS            .             .               .             NONE            .
    343  WSMADC    BS            .             .               .             NONE            .
    509  XMCDNDA   BS       125.32999          .               .             NONE            .
    717  XMGDNDB   BS        87.16216          .               .             NONE            .
    938  XMDDPCC   BS       409.64799          .               .             NONE            .
    941  XMGDPCC   BS       346.18659          .               .             NONE            .
   1146  XMDDPDD   BS       462.73165          .               .             NONE            .
   1149  XMGDPDD   BS       391.04675          .               .             NONE            .
   1354  XMDDPDE   BS       566.28752          .               .             NONE            .
   1357  XMGDPDE   BS       478.56019          .               .             NONE            .
   1562  XMDDPDF   BS      1375.62293          .               .             NONE            .
   1565  XMGDPDF   BS      1162.51616          .               .             NONE            .
   1770  XMDDPDG   BS       284.03898          .               .             NONE            .
   1773  XMGDPDG   BS       552.67859          .               .             NONE            .
   1978  XMDDPDH   BS       816.78714          .               .             NONE            .
   1981  XMGDPDH   BS      1685.24184          .               .             NONE            .
   2189  XMGDPDI   BS       285.90768          .               .             NONE            .
   2394  XMDDPDJ   BS      1560.20249          .               .             NONE            .
   2397  XMGDPDJ   BS      1318.50135          .               .             NONE            .
   2598  XMFDNDK   BS      1405.92069          .               .             NONE            .
   2813  XMGDPDL   BS       583.69958          .               .             NONE            .
   3021  XMGDPDM   BS       211.76827          .               .             NONE            .
   3437  XMGDPDC   BS       171.77579          .               .             NONE            .
   3858  XMDDPDC   BS       667.98991          .               .             NONE            .
   3860  XMFDPDQ   BS       266.22916          .               .             NONE            .
   3861  XMGDPDQ   BS       433.14593          .               .             NONE            .
   4069  XMGDPDR   BS       122.47914          .               .             NONE            .
   4267  XSMFDPDF  BS            .             .               .             NONE            .
   4895  XSMADCDJ  BS            .             .               .             NONE            .
   5775  YMBMBDA   BS       927.90241          .               .             NONE            .
   5815  YMAMBCA   BS       645.32027          .               .             NONE            .
   6015  YMBMBDG   BS      2610.84309          .               .             NONE            .
   6049  YMAMACH   BS            .             .               .             NONE            .
   6055  YMBMBDI   BS      2146.38281          .               .             NONE            .
   6131  YMCMCDK   BS            .             .               .             NONE            .
   6215  YMBMBDL   BS      4321.52000          .               .             NONE            .
   6255  YMBMBDM   BS      1567.85832          .               .             NONE            .
   6315  YMBMBDO   BS      1271.76801          .               .             NONE            .
 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ...LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

   6455  YMBMBQR   BS      506.79566         .                .              NONE            .
   6800  SS1DG     BS          .             .                .              NONE            .
   6801  SS1DI     BS          .             .                .              NONE            .
   6802  SS1DJ     BS          .             .                .              NONE            .
   6803  SS1DL     BS          .             .                .              NONE            .
   6804  SS1DM     BS          .             .                .              NONE            .
   6805  SS1DP     BS          .             .                .              NONE            .
   6806  SS1DQ     BS          .             .                .              NONE            .
   6807  SS2DF     BS          .             .                .              NONE            .
   6809  SS2DI     BS          .             .                .              NONE            .
   6811  SS2DL     BS          .             .                .              NONE            .
   6812  SS2DM     BS          .             .                .              NONE            .
   6815  S1DF      BS          .             .                .              NONE            .
   6817  S3DF      BS          .             .                .              NONE            .
   6818  S1DG      BS          .             .                .              NONE            .
   6820  S3DG      BS          .             .                .              NONE            .
   6821  S1DI      BS          .             .                .              NONE            .
   6823  S3DI      BS          .             .                .              NONE            .
   6824  S1DJ      BS          .             .                .              NONE            .
   6825  S2DJ      BS          .             .                .              NONE            .
   6826  S3DJ      BS          .             .                .              NONE            .
   6829  S3DL      BS          .             .                .              NONE            .
   6830  S1DM      BS          .             .                .              NONE            .
   6831  S2DM      BS          .             .                .              NONE            .
   6832  S3DM      BS          .             .                .              NONE            .
   6833  S1DP      BS          .             .                .              NONE            .
   6834  S2DP      BS          .             .                .              NONE            .
   6835  S3DP      BS          .             .                .              NONE            .
   6836  S1DQ      BS          .             .                .              NONE            .
   6837  S2DQ      BS          .             .                .              NONE            .
   6838  S3DQ      BS          .             .                .              NONE            .
   6839  CC1DN     BS          .             .                .              NONE            .
   6840  CC1DP     BS          .             .                .              NONE            .
   6841  CC1MA     BS          .             .                .              NONE            .
   6842  CC1MB     BS    14398.39058         .                .              NONE            .
   6843  CC1MC     BS          .             .                .              NONE            .
   6844  CC1MD     BS          .             .                .              NONE            .
   6845  CC1PA     BS          .             .                .              NONE            .
   6846  CC1PB     BS          .             .                .              NONE            .
   6847  C1DN      BS          .             .                .              NONE            .
   6849  C1DP      BS          .             .                .              NONE            .
   6852  C2MA      BS          .             .                .              NONE            .
   6853  C1MB      BS         .96908         .                .              NONE            .
   6854  C2MB      BS         .03092         .                .              NONE            .
   6857  C1MD      BS          .             .                .              NONE            .
   6859  C1PA      BS          .             .                .              NONE            .
   6861  C1PB      BS          .             .                .              NONE            .
   6881  TPIT      BS   217964.46788      1.00000             .              NONE            .
   6882  TFRT      BS   156660.25761      1.00000             .              NONE            .
   6883  TASH      BS     3018.55324      1.00000             .              NONE            .
   6884  TSCI      BS          .          1.00000             .              NONE            .
```

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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                              PAGE    23 -  74/179
 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

   6885  TSC2      BS         .           1.00000          .             NONE            .
   6886  TWSH      BS    27356.94210      1.00000          .             NONE            .
   6887  TREF      BS      892.70022      1.00000          .             NONE            .
   6888  TSTC      BS     5064.15472      1.00000          .             NONE            .
   6889  TBRN      BS         .           1.00000          .             NONE            .
   6894  IN12DL    IV         .              .             .            1.00000          .
   6896  IN12DP    IV         .              .             .            1.00000          .
   6897  IN12DC    IV         .              .             .            1.00000          .
   6898  IN23DF    IV         .              .             .            1.00000          .
   6899  IN23DG    IV         .              .             .            1.00000          .
   6901  IN23DJ    IV         .              .             .            1.00000          .
   6903  IN23DM    IV         .              .             .            1.00000          .
   6904  IN23DP    IV         .              .             .            1.00000          .
   6905  IN23DC    IV         .              .             .            1.00000          .
   6906  IM12DN    IV         .              .             .            1.00000          .
   6907  IM12DP    IV         .              .             .            1.00000          .
A  6909  IM12MB    IV      1.00000           .             .            1.00000          .
   6910  IM12MC    IV         .              .             .            1.00000          .
   6911  IM12MD    IV         .              .             .            1.00000          .
   6912  IM12PA    IV         .              .             .            1.00000          .
   6913  IM12PB    IV         .              .             .            1.00000          .
```

Case 3: Spec. = 1.2 lb SO_2/MMBtu

```
SECTION 1 - ROWS

 NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

       1  COSTTOTL  BS   543834.11199    543834.11199-          NONE            NONE          1.00000
       2  COSTPIT   EQ        .               .                  .               .            1.00000
       3  COSTFRT   EQ        .               .                  .               .            1.00000
       4  COSTASH   EQ        .               .                  .               .            1.00000
       5  COSTSC1   EQ        .               .                  .               .            1.00000
       6  COSTSC2   EQ        .               .                  .               .            1.00000
       7  COSTWSH   EQ        .               .                  .               .            1.00000
       8  COSTREF   EQ        .               .                  .               .            1.00000
       9  COSTSTO   EQ        .               .                  .               .            1.00000
      10  COSTBRN   EQ        .               .                  .               .            1.00000
      11  AMA       BS     6884.98408     43115.01592            NONE     50000.00000            .
      12  AMB       BS     7649.43175     42350.56825            NONE     50000.00000            .
      13  AMC       BS        .           50000.00000            NONE     50000.00000            .
      14  AMD       UL     7000.00000         .                  NONE      7000.00000         5.25304
      15  AME       UL        .               .                  NONE           .             3.53010
      16  AMF       UL     8000.00000         .                  NONE      8000.00000         8.88596
      17  AMG       UL     8000.00000         .                  NONE      8000.00000        13.37522
      18  AMH       UL        .               .                  NONE           .             5.91787
      19  DDA       EQ    18684.00000         .           18684.00000     18684.00000         1.34222-
      20  DDB       EQ    12994.00000         .           12994.00000     12994.00000         1.34222-
      21  DDC       EQ    17726.00000         .           17726.00000     17726.00000         1.15012-
      22  DDD       EQ    20023.00000         .           20023.00000     20023.00000         1.19736-
      23  DDE       EQ    24504.00000         .           24504.00000     24504.00000         1.17726-
      24  DDF       EQ    59525.00000         .           59525.00000     59525.00000         1.02693-
      25  DDG       EQ    64862.00000         .           64862.00000     64862.00000         1.03975-
      26  DDH       EQ    64937.00000         .           64937.00000     64937.00000         1.24821-
      27  DDI       EQ    43219.00000         .           43219.00000     43219.00000          .97916-
      28  DDJ       EQ    67512.00000         .           67512.00000     67512.00000         1.01940-
      29  DDK       EQ    33461.00000         .           33461.00000     33461.00000         1.18968-
      30  DDL       EQ    87017.00000         .           87017.00000     87017.00000          .95508-
      31  DDM       EQ    31570.00000         .           31570.00000     31570.00000         1.04800-
      32  DDN       EQ   115682.00000         .          115682.00000    115682.00000         1.07977-
      33  DDO       EQ    25608.00000         .           25608.00000     25608.00000         1.25959-
      34  DDP       EQ    51307.00000         .           51307.00000     51307.00000          .98802-
      35  DDQ       EQ    31488.00000         .           31488.00000     31488.00000         1.01582-
      36  DDR       EQ    18259.00000         .           18259.00000     18259.00000         1.29335-
      37  EDA       UL    22420.79297         .                  NONE     22420.79297          .19795
      38  EDB       UL    15592.79688         .                  NONE     15592.79688          .19795
      39  EDC       UL    21271.19531         .                  NONE     21271.19531          .15603
      40  EDD       UL    24027.59375         .                  NONE     24027.59375          .15428
      41  EDE       UL    29404.79297         .                  NONE     29404.79297          .15588
      42  EDF       UL    71429.93750         .                  NONE     71429.93750          .07874
      43  EDG       UL    77834.37500         .                  NONE     77834.37500          .09181
      44  EDH       UL    77924.37500         .                  NONE     77924.37500          .15024
      45  EDI       UL    51862.78906         .                  NONE     51862.78906          .08773
      46  EDJ       UL    81014.37500         .                  NONE     81014.37500          .07874
      47  EDK       UL    40153.19141         .                  NONE     40153.19141          .16093
      48  EDL       UL   104420.37500         .                  NONE    104420.37500          .10271
      49  EDM       UL    37883.99219         .                  NONE     37883.99219          .08933
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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                      PAGE   20  -  74/179

 NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

     50  EDN       UL   138818.37500          .              NONE     138818.37500          .16967
     51  EDO       UL    30729.59375          .              NONE      30729.59375          .19064
     52  EDP       UL    61568.38672          .              NONE      61568.38672          .08358
     53  EDQ       UL    37785.59375          .              NONE      37785.59375          .08879
     54  EDR       UL    21910.79297          .              NONE      21910.79297          .18978
     55  SIZXDF    EQ          .              .           .                  .              .26998
     56  SIZXDG    EQ          .              .           .                  .              .26998
     57  SIZXDI    EQ          .              .           .                  .              .26998
     58  SIZXDJ    EQ          .              .           .                  .              .26998
     59  SIZXDL    EQ          .              .           .                  .              .26998
     60  SIZXDM    EQ          .              .           .                  .              .26998
     61  SIZXDP    EQ          .              .           .                  .              .26998
     62  SIZXDQ    EQ          .              .           .                  .              .26998
     63  E01DF     BS         .57031-        .57031          NONE                .              .
     64  E01DG     BS         .77271-        .77271          NONE                .              .
     65  E01DI     BS         .44814-        .44814          NONE                .              .
     66  E01DJ     BS         .42815-        .42815          NONE                .              .
     67  E01DL     BS         .79408-        .79408          NONE                .              .
     68  E01DM     BS         .27344-        .27344          NONE                .              .
     69  E01DP     BS         .40371-        .40371          NONE                .              .
     70  E01DQ     BS         .17051-        .17051          NONE                .              .
     71  E02DF     BS         .42969-        .42969          NONE                .              .
     72  E02DG     BS         .22729-        .22729          NONE                .              .
     73  E02DI     BS         .55186-        .55186          NONE                .              .
     74  E02DJ     BS         .57185-        .57185          NONE                .              .
     75  E02DL     BS         .20592-        .20592          NONE                .              .
     76  E02DM     BS         .72656-        .72656          NONE                .              .
     77  E02DP     BS         .59629-        .59629          NONE                .              .
     78  E02DQ     BS         .82949-        .82949          NONE                .              .
     79  E03DF     UL          .              .              NONE                .         4042.80000
     80  E03DG     UL          .              .              NONE                .         4042.80000
     81  E03DI     UL          .              .              NONE                .         4042.80000
     82  E03DJ     UL          .              .              NONE                .         4042.80000
     83  E03DL     UL          .              .              NONE                .         4042.80000
     84  E03DM     UL          .              .              NONE                .         4042.80000
     85  E03DP     UL          .              .              NONE                .         4042.80000
     86  E03DQ     UL          .              .              NONE                .         4042.80000
     87  E05DF     BS        1.00000          .              NONE          1.00000              .
     88  E05DG     BS        1.00000          .              NONE          1.00000              .
     89  E05DI     BS        1.00000          .              NONE          1.00000              .
     90  E05DJ     BS        1.00000          .              NONE          1.00000              .
     91  E05DL     BS        1.00000          .              NONE          1.00000              .
     92  E05DM     BS        1.00000          .              NONE          1.00000              .
     93  E05DP     BS        1.00000          .              NONE          1.00000              .
     94  E05DQ     BS        1.00000          .              NONE          1.00000              .
     95  E06DF     EQ          .              .           .                  .         2017.20000-
     96  E06DG     EQ          .              .           .                  .         2017.20000-
     97  E06DI     EQ          .              .           .                  .         2017.20000-
     98  E06DJ     EQ          .              .           .                  .         2017.20000-
     99  E06DL     EQ          .              .           .                  .         2017.20000-
    100  E06DM     EQ          .              .           .                  .         2017.20000-
```

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D.C.

```
  NUMBER  ...ROW..  AT  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY

     101  EQ6DP     EQ        .               .               .               .          2017.20000-
     102  EQ6DQ     EQ        .               .               .               .          2017.20000-
     103  HDF       EQ        .               .               .               .              .26998
     104  HDG       EQ        .               .               .               .              .26998
     105  HDI       EQ        .               .               .               .              .26998
     106  HDJ       EQ        .               .               .               .              .26998
     107  HDL       EQ        .               .               .               .              .26998
     108  HDM       EQ        .               .               .               .              .26998
     109  HDP       EQ        .               .               .               .              .26998
     110  HDQ       EQ        .               .               .               .              .26998
     111  JDF       EQ        .               .               .               .              .03150
     112  JDG       EQ        .               .               .               .              .03150
     113  JDI       EQ        .               .               .               .              .03150
     114  JDJ       EQ        .               .               .               .              .03150
     115  JDL       EQ        .               .               .               .              .03150
     116  JDM       EQ        .               .               .               .              .03150
     117  JDP       EQ        .               .               .               .              .03150
     118  JDQ       EQ        .               .               .               .              .03150
     119  SIZYCN    EQ        .               .               .               .             1.90000
     120  SIZYDP    EQ        .               .               .               .             1.90000
 319 121  SIZYMA    EQ        .               .               .               .             1.40767
     122  SIZYMB    EQ        .               .               .               .             1.36800
     123  SIZYMC    EQ        .               .               .               .             1.01202
     124  SIZYMD    EQ        .               .               .               .             1.90000
     125  SIZYPA    EQ        .               .               .               .             1.90000
     126  SIZYPB    EQ        .               .               .               .             1.90000
A    127  EQ03DN    EQ        .               .               .               .                 .
A    128  EQ03DP    EQ        .               .               .               .                 .
     129  EQ03MA    EQ        .               .               .               .          3544.79846-
     130  EQ03MB    EQ        .               .               .               .          3830.40355-
A    131  EQ03MC    EQ        .               .               .               .                 .
A    132  EQ03MD    EQ        .               .               .               .                 .
A    133  EQ03PA    EQ        .               .               .               .                 .
A    134  EQ03PB    EQ        .               .               .               .                 .
     135  FDN       EQ        .               .               .               .             1.90000
     136  FDP       EQ        .               .               .               .             1.90000
     137  FMA       EQ        .               .               .               .             1.40767
     138  FMB       EQ        .               .               .               .             1.36800
     139  FMC       EQ        .               .               .               .             1.01202
     140  FMD       EQ        .               .               .               .             1.90000
     141  FPA       EQ        .               .               .               .             1.90000
     142  FPB       EQ        .               .               .               .             1.90000
```

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SECTION 2 - COLUMNS

 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

    252  WMFDN     BS    3130.20596          .               .              NONE            .
    253  WMGFN     BS    2177.58003          .               .              NONE            .
    254  WMHDN     BS         .              .               .              NONE            .
    255  WSMAPG    BS    3197.78484          .               .              NONE            .
    303  WSMADI    BS    2130.75538          .               .              NONE            .
    320  WSMBDL    BS     449.43175          .               .              NONE            .
    327  WSMADM    BS    1556.44386          .               .              NONE            .
    338  WSMDDP    BS    1667.01427          .               .              NONE            .
    509  XMGDNDA   BS     634.06352          .               .              NONE            .
    717  XMGDNDB   BS     440.96665          .               .              NONE            .
    940  XMFDPDC   BS     479.64270          .               .              NONE            .
    941  XMGDPDC   BS     333.67151          .               .              NONE            .
   1148  XMFDPDD   BS     541.79652          .               .              NONE            .
   1149  XMGDPDD   BS     376.90992          .               .              NONE            .
   1356  XMFDPDE   BS     663.04662          .               .              NONE            .
   1357  XMGDPDE   BS     461.25956          .               .              NONE            .
   1562  XMDDFDF   BS     363.34477          .               .              NONE            .
   1980  XMFDPDH   BS    1336.98428          .               .              NONE            .
   1981  XMCDPDH   BS    1457.00568          .               .              NONE            .
   2394  XMDCPDJ   BS      85.02681          .               .              NONE            .
   2396  XMFDPDJ   BS     942.91240          .               .              NONE            .
   2588  XMFDNDK   BS     905.41152          .               .              NONE            .
   2589  XMGDNDK   BS     629.86472          .               .              NONE            .
   3437  XMGDPDO   BS     869.03756          .               .              NONE            .
   4069  XMGDPDR   BS     619.64065          .               .              NONE            .
   4266  XSMDCPDF  BS    2127.03333          .               .              NONE            .
   4890  XSMCDPDJ  BS    1734.50514          .               .              NONE            .
   4891  XSMEDPDJ  BS         .              .               .              NONE            .
   5730  XSMDDPDC  BS    1023.07568          .               .              NONE            .
   5775  YMBMBDA   BS     243.61910          .               .              NONE            .
   5815  YMBMBCB   BS     169.42770          .               .              NONE            .
   6015  YMBMBDG   BS      38.92650          .               .              NONE            .
   6055  YMBMBDH   BS     202.44887          .               .              NONE            .
   6095  YMBMBDI   BS      25.93774          .               .              NONE            .
   6135  YMBMBDJ   BS     247.01273          .               .              NONE            .
   6215  YMBMBDL   BS    1256.30805          .               .              NONE            .
   6255  YMBMBDM   BS      18.94663          .               .              NONE            .
   6335  YMBMBDO   BS     333.90062          .               .              NONE            .
   6375  YMBMBCP   BS     672.65560          .               .              NONE            .
   6415  YMBMBDQ   BS     412.82050          .               .              NONE            .
   6455  YMBMBCP   BS     238.07756          .               .              NONE            .
   6529  YSMAMACC  BS         .              .               .              NONE            .
   6655  YSMBMBDL  BS    3339.91862          .               .              NONE            .
   6701  YSMCMCDM  BS         .              .               .              NONE            .
   6799  SS1DF     BS   50840.33578          .               .              NONE            .
   6800  SS1DG     BS   64198.69331          .               .              NONE            .
   6801  SS1DI     BS   42777.02154          .               .              NONE            .
   6802  SS1DJ     BS   41458.12964          .               .              NONE            .
   6803  SS1DL     BS   65609.53859          .               .              NONE            .
 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

   6804  SS1DM     BS     31247.14979         .               .             NONE           .
   6805  SS1DP     BS     35844.96340         .               .             NONE           .
   6806  SS1DQ     BS     24453.54778         .               .             NONE           .
   6807  SS2DF     BS    157604.90628         .               .             NONE           .
   6808  SS2DG     BS    378772.09196         .               .             NONE           .
   6809  SS2DI     BS    252304.29477         .               .             NONE           .
   6810  SS2DJ     BS    128520.09208         .               .             NONE           .
   6811  SS2DL     BS    145531.82110         .               .             NONE           .
   6812  SS2DM     BS    184358.08711         .               .             NONE           .
   6813  SS2DP     BS    123519.28103         .               .             NONE           .
   6814  SS2DQ     BS     75205.93334         .               .             NONE           .
   6815  S1DF      BS          .42969         .               .             NONE           .
   6816  S2DF      BS          .57031         .               .             NONE           .
   6817  S3DF      BS         .               .               .             NONE           .
   6818  S1DG      BS          .22729         .               .             NONE           .
   6819  S2DG      BS          .77271         .               .             NONE           .
   6820  S3DG      BS         .               .               .             NONE           .
   6821  S1DI      BS          .55186         .               .             NONE           .
   6822  S2DI      BS          .44814         .               .             NONE           .
   6823  S3DI      BS         .               .               .             NONE           .
   6824  S1DJ      BS          .57185         .               .             NONE           .
   6825  S2DJ      BS          .42815         .               .             NONE           .
   6826  S3DJ      BS         .               .               .             NONE           .
   6827  S1DL      BS          .20592         .               .             NONE           .
   6828  S2DL      BS          .79408         .               .             NONE           .
   6829  S3DL      BS         .               .               .             NONE           .
   6830  S1DM      BS          .72656         .               .             NONE           .
   6831  S2DM      BS          .27344         .               .             NONE           .
   6832  S3DM      BS         .               .               .             NONE           .
   6833  S1DP      BS          .59629         .               .             NONE           .
   6834  S2DP      BS          .40371         .               .             NONE           .
   6835  S3DP      BS         .               .               .             NONE           .
   6836  S1DQ      BS          .82949         .               .             NONE           .
   6837  S2DQ      BS          .17051         .               .             NONE           .
   6838  S3DQ      BS         .               .               .             NONE           .
   6839  CC1DN     BS         .               .               .             NONE           .
   6840  CC1DP     BS         .               .               .             NONE           .
   6841  CC1MA     BS         .               .               .             NONE           .
   6842  CC1MB     BS      7200.00000         .               .             NONE           .
   6843  CC1MC     BS         .               .               .             NONE           .
   6844  CC1MD     BS         .               .               .             NONE           .
   6845  CC1PA     BS         .               .               .             NONE           .
   6846  CC1PB     BS         .               .               .             NONE           .
   6847  C1DN      BS         .               .               .             NONE           .
   6849  C1DP      BS         .               .               .             NONE           .
   6851  C1MA      BS         .               .               .             NONE           .
   6853  C1MB      BS         1.00000         .               .             NONE           .
   6857  C1MD      BS         .               .               .             NONE           .
   6859  C1PA      BS         .               .               .             NONE           .
   6861  C1PB      BS         .               .               .             NONE           .
   6881  TRIT      BS    211340.09894      1.00000            .             NONE           .
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MPSX-PTF13     EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 3                                                      PAGE    24  -  74/179

 NUMBER  .COLUMN.  AT  ...ACTIVITY...  ..INPUT COST..  ..LOWER LIMIT.  ..UPPER LIMIT.  .REDUCED COST.

   6882  TERT      BS   148897.94665         1.00000          .              NONE             .
   6883  TASH      BS     3489.39500         1.00000          .              NONE             .
   6884  TSC1      BS   113448.07149         1.00000          .              NONE             .
   6885  TSC2      BS    45564.63999         1.00000          .              NONE             .
   6886  TWSH      BS    13680.00000         1.00000          .              NONE             .
   6887  TREF      BS      446.40000         1.00000          .              NONE             .
   6888  TSTC      BS     6567.55992         1.00000          .              NONE             .
   6889  TBRN      BS          .             1.00000          .              NONE             .
   6890  IN12DF    IV        1.00000          .               .           1.00000      2017.20000
   6891  IN12DG    IV        1.00000          .               .           1.00000      2017.20000
   6892  IN12DI    IV        1.00000          .               .           1.00000      2017.20000
   6893  IN12DJ    IV        1.00000          .               .           1.00000      2017.20000
   6894  IN12DL    IV        1.00000          .               .           1.00000      2017.20000
   6895  IN12DM    IV        1.00000          .               .           1.00000      2017.20000
   6896  IN12DP    IV        1.00000          .               .           1.00000      2017.20000
   6897  IN12DQ    IV        1.00000          .               .           1.00000      2017.20000
   6906  IM12DN    IV          .              .               .           1.00000           .
   6907  IM12DP    IV          .              .               .           1.00000           .
   6909  IM12MB    IV        1.00000          .               .           1.00000      3830.40355
   6910  IM12MC    IV          .              .               .           1.00000           .
   6911  IM12MD    IV          .              .               .           1.00000           .
   6912  IM12PA    IV          .              .               .           1.00000           .
   6913  IM12PB    IV          .              .               .           1.00000           .
```